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SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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Television Studio Practices Relative to Kinescope Recording

By HAROLD WRIGHT

If television studio practices are controlled, using the transmission waveform as the guide, consistent kinescope recording quality can be maintained. The waveform approach must be one which takes into account both peak-to-peak voltage conditions and waveform area balance. Inclusion of reference black and white in all possible shots will ensure consistent picture voltages to the kinescope recorder and permit retention of mood when the recording is reproduced. Careful attention to tonal balance of shots will produce balanced waveform areas. This is essential to stable reproduction on receivers not equipped with d-c restoration.

It was realized at an early stage in the development of Canadian television that due to the great distances involved, scattered population centers and time-zone differences, a great deal of television programming would be by way of kinescope recordings. This, coupled with an extremely rapid expansion of production facilities, presented a challenge in terms of both education and control. From an early stage groundwork was laid in the form of Technical and Program Staff education on which it was later possible to build a workable system of studio-practice control. This included the training of program producers, directors, designers and graphic artists in at least the rudiments of television transmission theory, particularly an understanding of video levels and video waveforms with their relationship to staging and production practices.

Coupled with adequate technical supervision of programs, this groundwork made possible a workable control. On the larger programs, the Technical Producer (equivalent to Technical Director in U.S. television) does not do any switching or perform other operations, and so he is able to take a more analytical and objective view of the program as a whole. It soon became evident that the critical area lay in the studio and that technical supervision and control of studio practices was essential to consistent kinescope recording quality.

C.B.C. policy in the supervision and control of studio practices is a realistic one. The basis for judgment is the adequacy of the final reproduction on the average home receiver.

It is not enough to consider only the quality of the release print as a piece of film. The problems of the reproducing equipment and the film-chain operator must be considered or the end result may still be mediocre. If all factors are considered, four main areas must be taken into account.

(1) The actual production of the program in the studio of origination.

(2) The television recording process (taken here to mean exposure and development of the negative and release print).

(3) The human element in the reproduction of the release print on a film camera chain.

Fig. 1. Kinescope recorder brightness adjustments being made in the Toronto recording room of the Canadian Broadcasting Corp.

Presented on October 7, 1955, at the Society's Convention at Lake Placid by Harold Wright, Canadian Broadcasting Corp., 354 Jarvis St., Toronto, Ont., Canada.
(This paper was received November 18, 1955.)

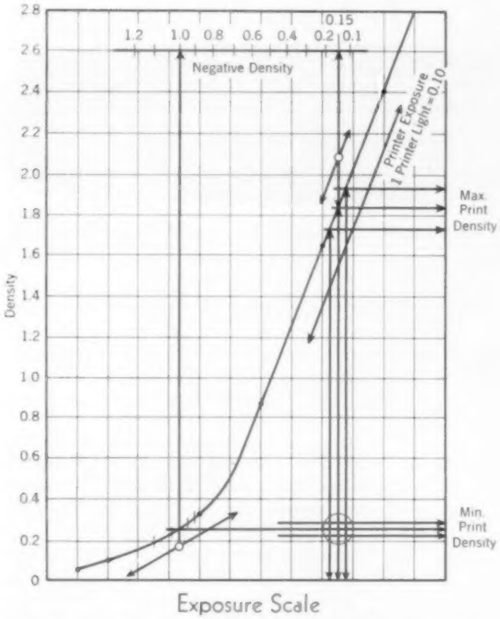

Fig. 2. Graph showing the release print tolerances for CBC kinescope recordings.

(4) The reproducing characteristics of the current crop of television receivers.

The kinescope recording area is eliminated as a variable. This has been accomplished as follows:

(a) Exact procedures are followed for adjustment of the kine-recording equipment prior to making each recording. This includes the use of a staircase or step-wedge generator combined with a brightness meter to ensure consistent brightness values at the face of the recorder kinescope when the recorder is fed a standard television picture signal. This is essential if consistent film exposure is to be achieved. Figure 1 shows these adjustments being made.

(b) For processing control, a rigid procedure of sensitometric and densitometric testing has been established. Complete and detailed records are kept and the overall tolerance of the entire recording process with respect to the standard reference staircase signal is held to ±0.1 density. Release prints have a density from 0.25 to 1.85. Figure 2 is a graphical representation of the data.

(c) Flow-metered replenishing is used in the developing tanks and the solution mixed for negative developer is also used for replenishing. When a tank is newly filled, sufficient potassium bromide is added to the developer to stabilize it so that developing of recordings may start immediately with normal replenisher flow "on."

(d) Adequate soundtracks have been achieved with synchronous magnetic film sound recorders. Electronic printing is used to produce a variable-area soundtrack on the release print.

(e) The entire recording, processing and printing operation is constantly and carefully supervised.

In film terminology, this is equivalent to a one-light process and it would seem therefore that the recording process has been changed from the status of an art to that of a controlled engineering process. This elimination of recording variables was essential before any adequate system of studio control could be made effective.

Area three takes into account the problems of level setting and its effect at the time the kinescope recording is reproduced. If adequate black and white references are included in the original shooting, particularly during the first thirty seconds of the program, then the reproduction of original lighting key and program mood will present few problems. The film-chain technician will have no difficulty establishing correct settings for gain and black level and the reproduction of tonal range will be correct. This is particularly important if good skin tone rendition is to be achieved.

Attaching step wedges and/or representative scenes at the head of each recording was considered but discarded since these would almost invariably be clipped off for the addition of spot commercials and station breaks. Steps are currently under way to make the inclusion of black and white references mandatory during the opening titles and scenes of programs which are to be recorded.

Figure 3 shows the picture and waveform for a scene which has neither reference whites nor reference blacks. If the film-chain operator attempts to obtain a full, one-volt signal by adjustment of the gain and black level, severe tonal distortion will occur and the end product will appear as shown in Fig. 4.

Area four considers that a very large proportion of current television receiver models are not equipped with a d-c restorer. Leaving out this important circuitry from the receivers has, in effect, taken away the standard video level reference and causes the receiver to


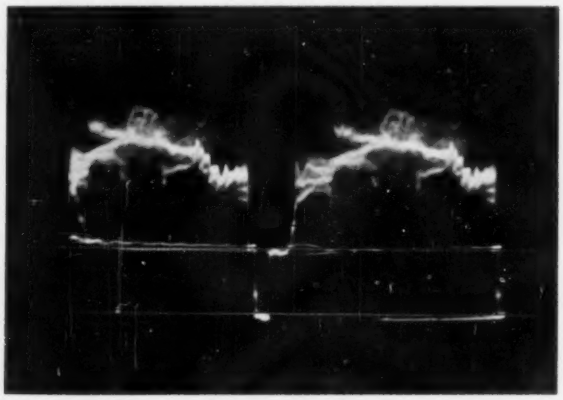

Fig. 3. Illustrating a television picture and its associated waveform when there are no reference blacks or whites in the scene.

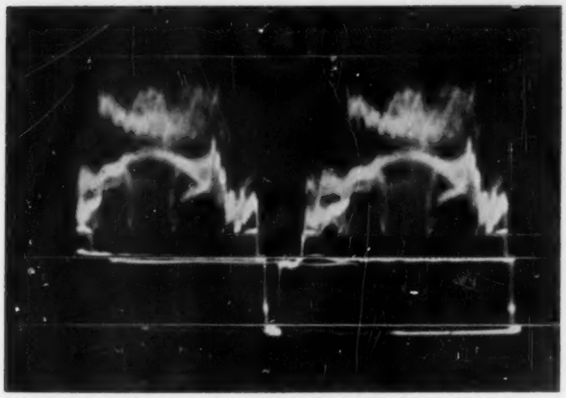

Fig. 4. The picture and waveform of Fig. 3 after the technician has readjusted gain and black level to obtain a full 1-v signal. Note the exaggeration and distortion of contrast.

function on an a-c basis. In an a-c coupled circuit the video signal seeks to establish an a-c axis in which the area of the waveform above the axis is equal to the area below the axis. This axis will shift as shooting angles and shot sizes change and will be different for low and high keylighting. If the receiver had d-c restoration, this would not be significant and the system would permit a great deal of latitude in terms of lighting and staging effects.

But with unrestored receivers the shifting a-c axis with its attendant screen brightness changes will frequently be sufficient to nullify completely the original effect. If a brightly lighted, high-key scene in a variety show is followed by a long shot of the artist against a dark background, then reproduction of this second shot under unrestored conditions will produce a gray and usually noisy background coupled with highlight saturation. This latter is most serious since it destroys skin tone and facial detail. To avoid these effects it is necessary to assess the outgoing video signal in terms of waveform area as well as peak-to-peak voltages. If staging, shooting and lighting are arranged so that a reasonable area balance exists in the light and dark portions of the scene, then a waveform will result which will have reasonably balanced areas about an axis assumed to lie in the middle of the tonal range. Under these conditions, reproduction

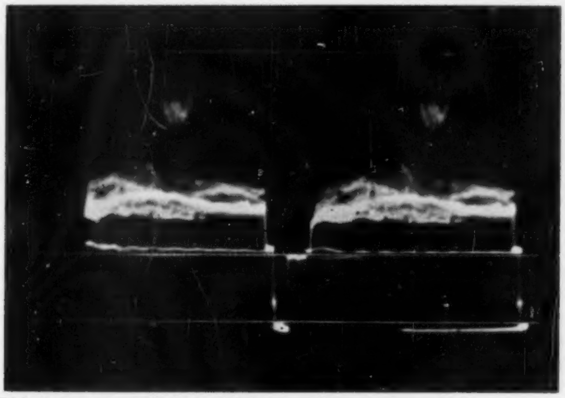

Fig. 5. The picture and waveform for a low-key long shot. This is the type of shot which reproduces very poorly on unrestored receivers.

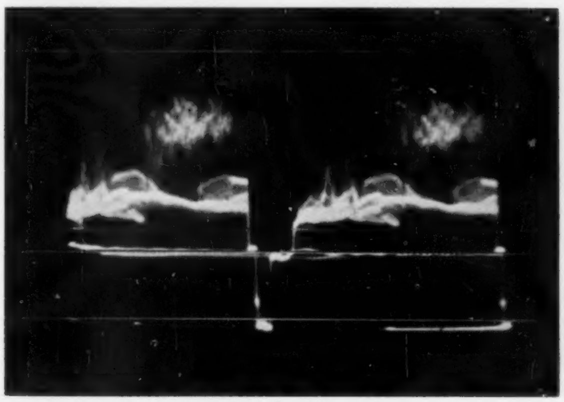

Fig. 6. Showing the effect on the picture and waveform when the shot of Fig. 5 is tightened.

Fig. 7. A normal scene with normal references and levels.

Fig. 8. The same scene shown in Fig. 7 but with a 10% increase in black level.

of the signal will be satisfactory even on unrestored receivers.

The picture and waveform shown in Fig. 5 are an example of unsatisfactoriness from the above viewpoint. In Fig. 6 the shot has been tightened somewhat, producing considerable improvement in the waveform area balance.

Area one, the production of the program, has been left until the last because it has tentacles in many departments which might be considered as nontechnical. This area may be further broken up somewhat as follows:

(a) Video control.
(b) Aperture setting.
(c) Shooting angles relative to lighting and settings.
(d) Staging practices.

Video Control

Video control is the most critical of these four factors. Careful and precise camera alignment is essential; regular frequent checking of waveform monitor calibration is required; and the picture monitors in any one control room should all match in terms of contrast and brightness. Image orthicons in any given studio should have approximately the same hours of usage in order to match adequately the pictures from the group. The final result is dependent on the skill and experience of the video technician. *If the result is to be good, then rigid attention must be given to level adjustments, with gain and black-level setting on the various cameras carefully matched.* Inadequate video control can be disastrous to the recording.

Figure 7 shows the picture for a normal scene. The picture has been enlarged from the kinescope recording negative. Figure 8 shows the effect of a 10% increase in black level and Fig. 9 shows the effect of a 10% decrease in black level. If such variations occur between the various cameras in one studio the effect is even more noticeable. When a recording turns out to be unsatisfactory, there is a tendency to blame staging or particularly lighting, but in viewing recordings it is usually almost impossible to distinguish between changes in lighting and changes caused by video adjustments. Effects lighting is of course excluded.

If the example shown in Fig. 10 is examined, the appearance of the picture would indicate that the frontlight had been increased. In this case, no change in lighting was made but the video gain was raised 10% over the normal value used to obtain the picture shown in Fig. 7.

It was soon established that responsibility for the control of video levels must lie with the originating studio. Once the test level has been established gain adjustments are not permitted either in master control or recording room.

Aperture Setting

Aperture settings will vary with lighting levels and camera tube age, but if a continuous stream of high-quality, matched shots is to leave the studio, then apertures must be carefully adjusted prior to each program. This may only be done in a satisfactory fashion after final lighting adjustments are completed. Ideally it should be done by having all the cameras in the studio shoot the same scene from as close to the same angle as possible and the apertures on each lens should then be adjusted to produce matched pictures. This procedure is obviously dependent on the previously mentioned accurate matching of picture and waveform monitors. The adjustments are made with reference to the waveform monitor. Starting with the lens at its smallest opening the aperture is increased until maximum expansion of the lowlights and middle lights occurs. We have found this to be a more satisfactory method of adjustment than the one where highlight saturation at the

Fig. 9. The scene shown in Fig. 7 but with a 10% decrease in black level.

Fig. 10. The scene shown in Fig. 7 but with an increase in gain of 10%.

image-orthicon knee is used as the guide. This method produces correct operation just over the knee of the image-orthicon characteristic and at the same time gives a more accurate tonal match. The final judgment should be passed by successively punching up the cameras on the switcher so that they may be viewed in rapid succession on the master picture and waveform monitor.

Shooting Angles Relative to Lighting and Settings

Widely different shooting angles are discouraged in C.B.C. television studios. Such wide differences in shooting angle invariably produce almost impossible problems for the lighting technicians and make it difficult, if not impossible, to match the pictures from the various cameras. If this situation is combined with poor staging practices the problem may be worsened. For example, if a setting has a large, fairly bright area adjacent to a large dark area and the cross-shooting employed alternately places the performer against a light and then a dark background, the effective shift in the transfer characteristic of the image orthicon due to redistribution will make it impossible to properly match the two pictures. This subject has been treated in detail by Janes and Rotow.*

Staging Practices

Staging practices are controlled in several ways. Internal regulations have been prepared and these are used as a reference by designers, producers, graphic artists, properties, technical producers and lighting crew chiefs. This helps to produce a reasonable amount of unity of approach and thinking relative to the problems of any one program. Pre-program meetings are held between the producer, designer, technical producer, lighting crew chief and audio technician with the intent of solving many of the problems on paper before they become physical ones on the studio floor.

Particular attention is given to those factors which tend to produce undesirable spurious effects in the camera tube. The studio contrast range, including settings, properties, costumes and the effect of lighting, is held to about 20 : 1. Sharp whites, such as white shirts, sheets, pillowcases, etc., are banned. Every effort is made to avoid the occurrence of black halo. This is a most unpleasant effect and pictures with black halos certainly cannot be considered to have photographic excellence. It has been found that the condition is reasonably easy to avoid if careful attention is given to the control of staging, lighting and particularly costume practices.

Fig. 11. A Baumgartner Reflectometer being used to calibrate samples of costume materials.

The internal regulations consist of a list of forty-three rules covering all phases of television studio operation. Boundaries for contrast in staging, graphic arts, costuming and properties are given as well as rules governing good production practices. As an example of this, here is an extract from the regulations:

> "*Rule 24.* In all types of programming, staging of action very close to set walls and backdrops shall be avoided.

DISCUSSION

"Staging action, particularly where it includes dialogue, very close to settings makes for an impossible situation in lighting and audio pickup. Good lighting dictates the use of backlighting in order to separate foreground objects from the background. But if the action moves in close to the backdrop, it will be impossible to hang backlights for such action and those hung for previous action further forward will overshoot and miss the actors entirely. The pictorial effect produced as the actor moves in and out of the backlight will not be a good one.

"From the audio standpoint, dialogue should cease when action moves closer than three feet from a wall. If this is not done, then boom and microphone shadows will certainly result. A particularly rough version of this problem is the one where the disgusted hero turns his back to the camera and addresses the wall. How then do we insert a microphone between the actor and the wall without getting mike shadows? A similar problem is presented by continuous dialogue from an actor who is approaching a doorway to leave a set."

The preceding quotation indicates the wide range covered and indicates that the control of studio practices is not confined to video only but takes into account the too often neglected audio aspect as well.

A somewhat new approach to the calibration of materials used in settings, costumes and graphic arts is currently under way. It has been felt by C.B.C. that the original method of calibration through studio cameras allowed too many variables. Camera-tube age, variations in video technique, errors in reading and other variables all helped to confuse the findings. It was felt that if all materials could be checked on a single measuring instrument the result would be more consistent. As a result, a Baumgartner Reflectometer was obtained with the light sensitive cells color corrected to match the characteristics of the 5820 image-orthicon camera tube. A studio gray scale was established in which television black was represented by materials with a reflectance of $3\frac{1}{2}\%$ and television white by materials with a reflectance of approximately 72%, giving a total contrast range of about 20 : 1. Steps in between were calculated in reflectance in steps and half steps in an approximately logarithmic fashion. Paint samples were initially checked on 4-in. square sections of plywood, greenboard and canvas, these three materials being the ones most commonly used in set construction. Cloth samples may be checked either in the bolt, as part of the costume, or as

* R. B. Janes and A. A. Rotow, "Light transfer characteristics of image orthicons," *RCA Rev.*, No. 9, Sept. 1950.

sample clippings, the only requirement being that a flat portion about 3 in. in diameter be available to set the instrument on.

Figure 11 shows the reflectometer being used to calibrate samples of costume materials.

It is hoped that this phase of the control of studio practices may be extended to the point where paints in the various colors may be premixed at the factory to a formula which will ensure that they will reproduce a given shade of gray when viewed under flat lighting on a television camera. In addition such an instrument in the hands of the costume designers would prevent many a costly and embarrassing error since materials could be checked even before they were purchased.

Conclusions

It would seem that the problem of control of television studio practices is much more than a technical one. It is reasonably easy to arrive at the necessary technical requirements and set forth the technical limitations of the system. It is another matter entirely to make the control system work. Artistic people are prone to cry that their creative efforts are being strangled. When the program is being viewed in the control room under almost laboratory-like conditions, many of the technical limitations are difficult to impress on the nontechnical mind. The latter is not inclined to accept the fact that the picture which looks so beautiful on the studio control-room monitor may be quite unsatisfactory when seen as a reproduction of a kinescope recording.

For studio practices to be successfully controlled it will be necessary to educate and convince the production staff in the necessary requirements and limitations. This alone will not be sufficient but must be followed up by careful and constant technical supervision of each program. The Technical Supervisor must be able to stand firm on issues of acceptability of any given picture or sound pickup, knowing that his decision will have the respect of production and the backing of station management.

Discussion

Frank N. Gillette (General Precision Laboratory): In the discussion of using the iris, I think you were referring to the use of the iris to adjust the light on the image orthicon to fit the studio conditions. There's also the point of depth of field.

Mr. Wright: If an iris adjustment is made on the show it's going to upset the depth of field for the cameraman. This would have to be determined before the show went on the air, and not suddenly sprung on the cameraman as a shift in adjustment. For this reason the servo control of apertures, in straight monochrome operation, not color operation, the servo mechanism on irises seems to lead sometimes to difficulty. I've run across cases where the video man thought he didn't have his aperture wide enough, started opening it without warning his cameraman, and let the cameraman be caught with too shallow a depth of field. It would have to be worked out during the last dress rehearsal test period before the show.

Robert G. Neuhauser (Radio Corp. of America): I agree with you on the control of the exposure of camera tubes. It's come to our attention that when a show is to be kinerecorded there should be some difference in the exposure of the camera tube to present a kinescope recording that has adequate effective resolution. This cannot be done by aperture correcting the electrical signal. Apparently it goes back to the image orthicon tune and the halo effect you get due to the electron re-distribution when operating over the knee. The image orthicon has a built-in halo cancellation in its electrical signal due to operation at some point over the knee. When you go through two kinescopes in the process, such as the kinescope recording tube plus the home receiver tube, this cancels out some of the halo that is introduced in those two processes. It should be a controlled thing and not way out of bounds as seen in a lot of broadcasts. Has this been your experience?

Mr. Wright: I think the tendency is for cameras to be run overexposed, because this encourages sloppy video operation. The AGC action of an overexposed image orthicon is such that the chap can sit back and smoke a cigar while the show is on. This is not, to my mind, video operation. I feel that a video operator cannot sit on his hands. If apertures are correctly set and the camera is lined up properly, at the proper light levels and the proper apertures, I feel that the quality of the signal will be considerably higher than if you set up everything to F/8 and pour on the light or some approach of that sort. I would agree that there is a critical point on the knee that gives generally better pictures.

Mr. Neuhauser: I wanted to make the point that there is apparently a different exposure necessary for a direct showing of a picture vs. a kinerecording since you have the halation of the kinescope recording as an additional thing in the recording process, so it requires a little more anti-halation effect.

Mr. Wright: No, I can't say I noticed this effect particularly, although now having become conscious of it perhaps I might.

Ellis W. D'Arcy (E.D.L. Co.): Have you employed scale stretching? I noticed you mentioned the use of a wedge pattern for adjusting the kinescope. I assume you're using some sort of a scale stretcher circuit in your amplifier to shape the video signal. Is that correct?

Mr. Wright: We do not use any gamma correction in our operation. We set up the kinerecorder on a staircase generator to produce given densities in the run of the mill release prints. From then on our approach is to provide that kinerecorder with a satisfactory waveform, which is one which includes proper reference blacks and whites in a reasonable total balance.

Mr. D'Arcy: How do you use the generator that you spoke about? The signal from it?

Mr. Wright: This is fed into the kinerecorder, and film is exposed from it to produce the equivalent of a photographic step wedge.

Mr. D'Arcy: You can then use it for linearity adjustments of any kind?

Mr. Wright: Yes, for the kinerecorder, the step wedge is fed into the kinerecorder in order to establish the right conditions of brightness on the face of the kinerecorder tube, to establish the conditions we want to achieve on our film.

An Electronic-Film Combination Apparatus for Motion-Picture and Television Production

By JAMES L. CADDIGAN
and
THOMAS T. GOLDSMITH, JR.

The system for recording of motion pictures in high quality on film combines the apparatus and techniques of television broadcasting studio practices with high-quality motion-picture film mechanisms for both 16mm and 35mm film in black-and-white and color. Details of the system and its methods of use are described. The particular apparatus for both the 16mm and 35mm versions is discussed.

Multiple-camera operation with simultaneous recording on the several films is monitored and controlled by television viewfinders so that the crew and program director may shoot continuously and rapidly in the manner of television broadcast control of multiple cameras, with a resultant direct high-quality film recording.

The assembly of the final master program is expedited by the director's constant planning and observation of the results of the several cameras as portrayed for him on television monitors, from which he calls for the desired "take" shots which are video switched to a final program monitor whose signals are simultaneously being recorded on a teletranscription cutting-guide film which serves as a cutting master for assembling the finished film product with a great saving of time.

Introduction

The Du Mont Electronicam TV-Film System utilizes television equipment as the electronic operating control for direct recording on motion-picture film. Both the 16mm and 35mm versions are in regular use in the New York City studios of Allen B. Du Mont Laboratories, Inc., the 16mm equipment at the Du Mont Telecenter on East 67th Street and the 35mm equipment at the Adelphi Theatre on 54th Street near Seventh Avenue.

This technical paper begins with a detailed description and illustrations of the electronic and film apparatus employed in this system. Then will follow a discussion of the uses and flexibility of the equipment for high-quality program recording.

The word "Electronicam" indicates the combination of electronic apparatus and motion-picture cameras in a system providing the speed, convenience, and flexibility of both the television and motion-picture apparatus.

The system employs several cameras, each equipped with a broadcast-quality image-orthicon television camera unit combined by optical integration with a professional motion-picture film direct-recording camera. Light from the scene to be recorded passes through a common lens to the film and the television pickup tube. Several cameras operate simultaneously on the stage. They are controlled from a television control room so that the camera crew and the control-room operators at all times operate in the manner of a television broadcasting crew shooting in long continuous takes. The composition of the program, the selection of shots and the direction of the show are accomplished by watching the pictures on the television monitors during the show. A film recording of the particular camera shots which are chosen in sequence by the director during the show is made in the current television-transcription practice so that an editing or cutting master film of the program is promptly available. This master film, along with the three continuously running films in a three-camera system, permits easy cutting of the final show from the high-quality negatives which have been exposed directly in the studio during the program.

Figure 1 shows the stage setting during the shooting of some color program material employing three of the Electronicam-16mm units.

Figure 2 shows the theater installation using three of the Electronicam-35mm units recording a *Jackie Gleason Show* in black-and-white.

Technical Features of the System

The overall system coordination for the stage, the control room, the film-transcription recording, the synchronization of sound and the cutting techniques will probably be better understood by referring to Fig. 3 which shows by block diagram the system characteristics. Three cameras, for example, operate from different angles in the studio, using the desired lenses to give close-up and wide-angle shots, upon instructions from the control-room staff. The picture signals are reproduced by television in the viewfinders so that the cameramen can properly compose the scenes desired as well as adjust the focus of the lens and dolly

Presented on October 6, 1955, at the Society's Convention at Lake Placid, N.Y., by James L. Caddigan and Thomas T. Goldsmith, Jr., Allen B. Du Mont Laboratories, Inc., Clifton, N.J. (This paper was received on October 6, 1955).

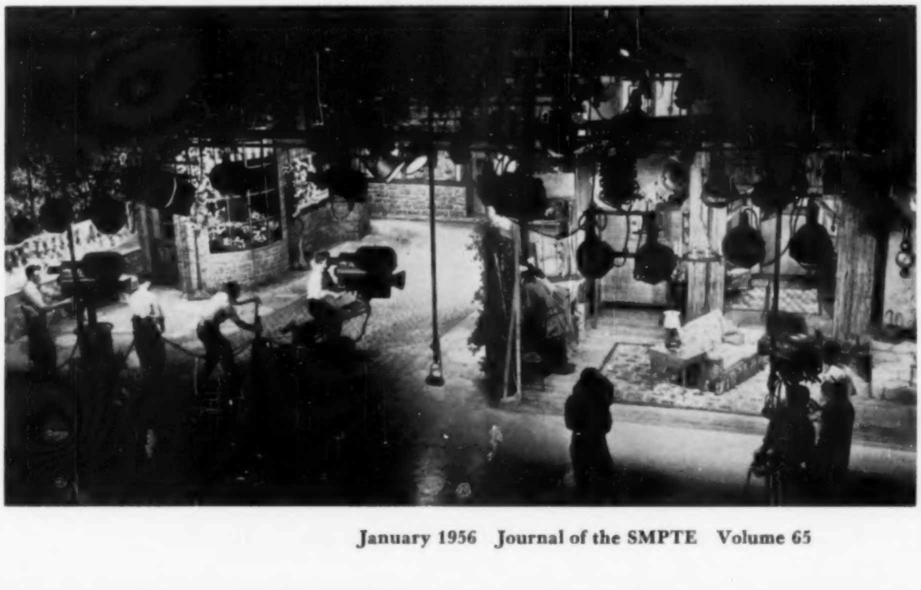

Fig. 1. Stage operation during the recording of a color program on Electronicam-16 with multiple cameras at Du Mont's 67th Street Studios.

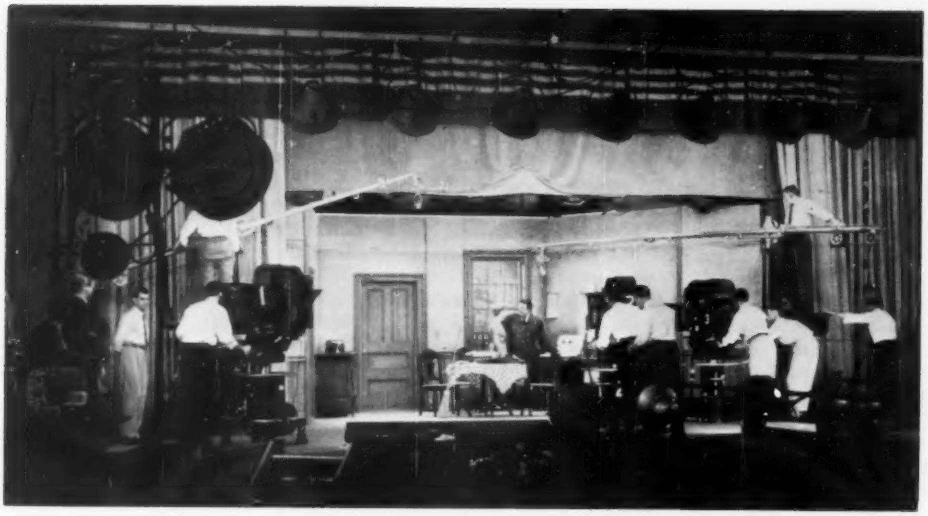

Fig. 2. Recording a Jackie Gleason Show on Adelphi Theater stage with multiple Electronicam-35 units.

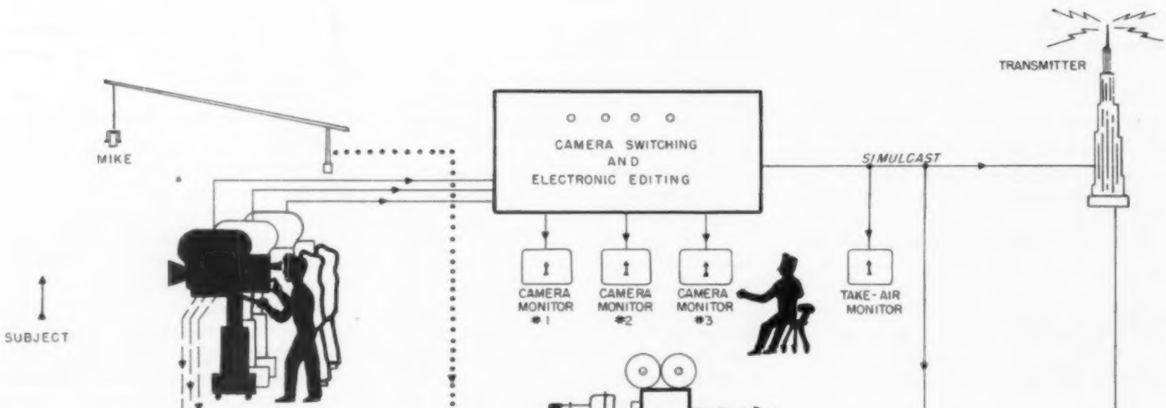

Fig. 3. Block diagram of Electronicam TV-Film System.

the cameras. The pictures are also reproduced in the control room on preview monitors for each camera and on a line monitor to which is switched the output of each camera in turn as it is selected by the program director. The program director is in contact with the stage crew by intercom phone to provide instructions during the course of the filming. The sound is picked up from the actors and the audience and recorded with the standard practices employed in the television and motion-picture arts.

The program which is selected by video switching also appears on a teletranscription monitor from which it is recorded on film which later serves as a cutting master for a final assembly of the finished program. The three cameras in addition to providing the television pictures for control during the show also record the program directly on film in the continuously running motion-picture mechanism. The sound recording, the teletranscription record and the film product of the several cameras are synchronously marked during the shooting and can then be edited and assembled quickly into the final film show. The end product, which is a program on film, can then be used for screen projection or for delayed broadcasting if desired. During the course of the show a simulcast television broadcast can take place.

The Electronicam-35 provides a high-quality simulcast type of television signal at all times whether or not the film is running. The Electronicam-16 in one form conserves stage lighting by time sharing of the picture between the film and the television, thus providing a television signal suitable for monitoring and control but not suitable for broadcast on a simulcast basis. Other forms of 16mm camera equipment, however, are free of this limitation.

The 16mm Equipment

Figure 4 is a simplified optical diagram of the Electronicam-16 mechanism. Here the scene being photographed is focussed by an objective lens through a shutter opening onto the 16mm film. When this shutter is in its closed position a precision front-surface mirror on the shutter blade mounted at 45° to the lens axis reflects the optical image to a prism along a side path. An aerial image would be formed at a similar distance to the film focal plane but along this side path. A field lens mounted at this position directs the sharply focussed scene through the prism and through the necessary mirrors to a relay lens which is adjusted to provide the correct magnification of the image to correspond to the normal picture area of the photosensitive surface of the television image-orthicon camera tube.

This time sharing characteristic of one form of the 16mm machine provides full sensitivity of film recording without any loss of light along that path and actuates

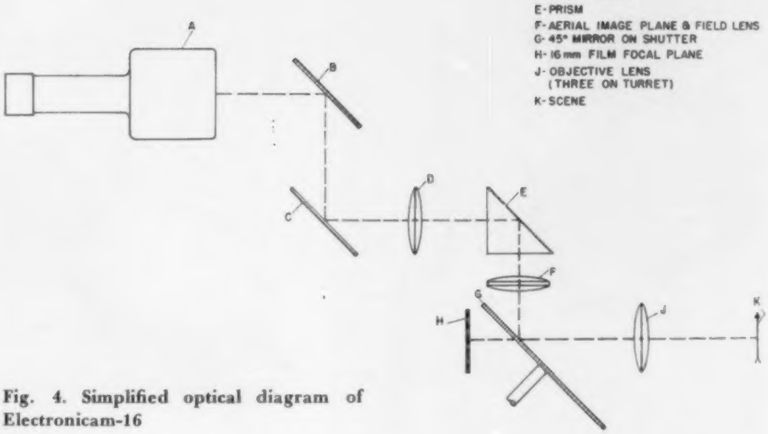

Fig. 4. Simplified optical diagram of Electronicam-16

the television system at a time when film would not normally be exposed anyway. Thus, exposure requirements are exactly the same as for a standard 16mm camera. Another form of 16mm machine provides the optical image at all times to both the film shutter path and the television path, thus providing simulcast quality on the television system.

Figure 5 shows the cameraman operating one of the Electronicam-16 units in recording a *Captain Video* sequence. His operational procedure is that of normal television shooting. He watches an electronic viewfinder to compose the proper framing of the picture and adjusts the sharpness of focus of the lens with his right hand on a remote control brought to the back of the camera. The panning handle in his left hand and the focussing arm in his right hand facilitate adjustment of the camera for desired framing in accordance with his judgment as well as instructions received over his headphone intercom system from the control room. When necessary, he can select any of the three lenses by a turret-change lever conveniently located at the rear of the camera.

Figure 6, a front view of the Electronicam-16, shows the multiple-lens turret and the blimp which encloses the motion-picture mechanism in a soundproof case. The secondary optical path

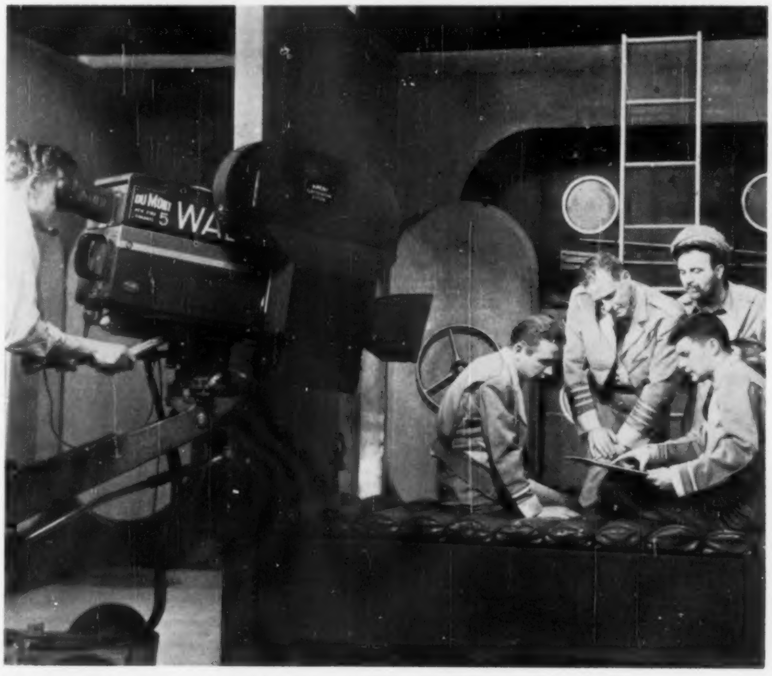

Fig. 5. Filming Captain Video sequence with 16mm unit, showing camerman's regular television controls for panning, viewfinding, ad lib focus and lens change.

Fig. 6. The blimped 16mm film unit with multi-lens turret and auxiliary optical path to television camera showing video cable and additional film control cable.

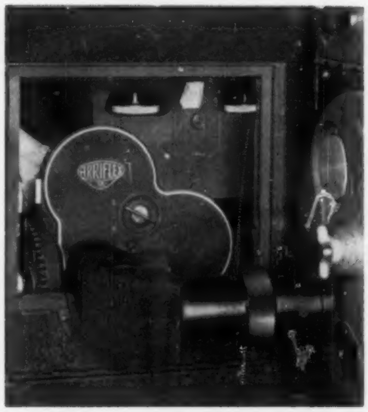

Fig. 7. Detailed view of Electronicam-16, showing modified Arriflex film camera and auxiliary optical path to TV unit.

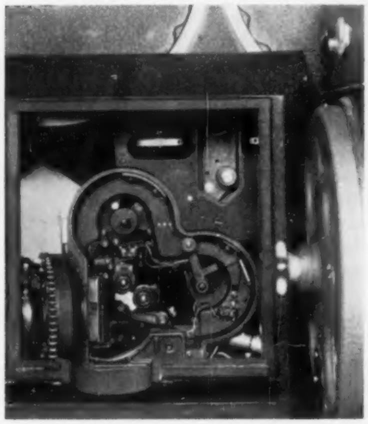

Fig. 8. Electronicam-16, showing film-loading area with buckle safety switches, turret control, and 1200-ft magazine.

Fig. 9. Electronicam-35 camera assembly with sound-proofing blimp, auxiliary optical path to TV unit and cradle head and dolly.

which leads from the lens to the television camera is also shown in Fig. 6. A closer view of this optical side assembly is illustrated in Fig. 7 showing the method of attachment to the professional modified and adapted Arriflex Camera. This side optical assembly and the cover of the Arriflex are readily removed to expose the film-loading area illustrated in Fig. 8. The remote-control, lens-turret mechanism can be seen in this Fig. 8. Safety circuits include buckle switches and loop protective switches. Necessary synchronous-marking circuits and exposure lamps have been built into the apparatus, operated remotely from the control room to leave the cameraman free for his normal television duties. The Electronicam-16 is equipped with large film magazines holding 1200 ft of standard film, thus permitting recording of at least one-half hour of continuous programming.

The 35mm Equipment

The 35mm form of the Electronicam System employs a camera assembly

illustrated in Fig. 9. It combines a modified and adapted Mitchell professional 35mm mechanism for the film and the professional Du Mont Image Orthicon Television Camera. Again, a common lens sends light both to the film and, through a side optical path, into the television camera. The cradle head and the dolly arrangement, shown in Fig. 9, permit easy handling of this equipment on the stage. The blimp provides soundproofing for the film-transport mechanism.

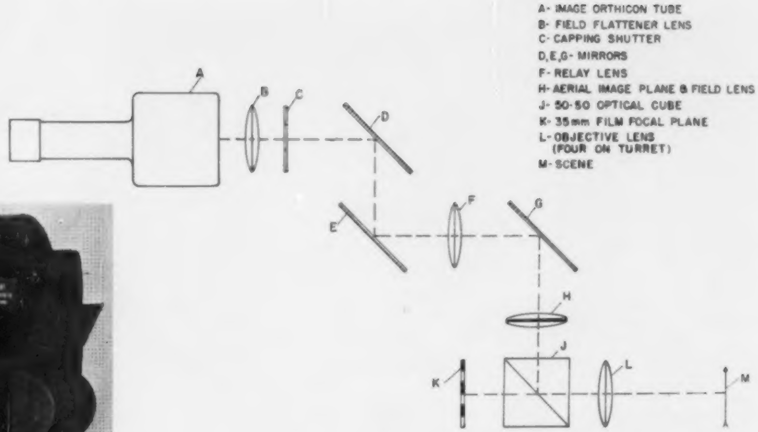

Fig. 10. Simplified optical diagram for Electronicam-35.

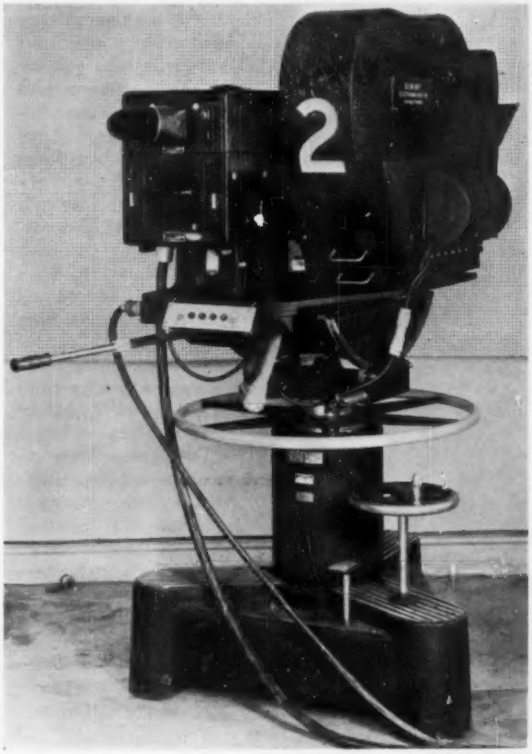

Fig. 11. Electronicam-35 from operator's position, show-focus handle for lens adjustment, lens selector push-buttons, dollying and panning facilities, and the electronic viewfinder by which the cameraman composes and controls his shooting.

The internal structure of the optical system in the Electronicam-35 is better understood from Fig. 10. Here an optical cube is employed to provide simultaneous images both to the film plane and to the television pickup tube. The units are so constructed as to permit quick interchange of these optical cubes so as to provide optimum match of light sensitivity over the film and television paths. With black-and-white shooting on Eastman Tri X stock a 50/50 light split is accomplished in the optical cube resulting in excellent exposure for scenes illuminated at approximately 250 ft-c at T5.6. The television pictures are of excellent quality.

The optical cube may be changed to one providing 80% light to the film and only 20% light to the television camera when Eastman negative color film is employed using stage illumination of approximately 800 ft-c at a lens opening of T4.0. Exact framing of the scene is insured by this optical system which has no parallax by virtue of the use of a common lens. Factory adjustment of the apparatus insures appropriate magnification of the image on the television screen from the television path as well as insures sharpness of focus on the television camera tube at the same time sharp focus is produced in the film plane. The image-orthicon tube may be moved during this factory adjustment but is subsequently locked in position during actual shooting. The focus handle operated by the cameraman moves lens "L."

Selection of any one lens is accomplished by the cameraman through remote pushbutton controls brought to a convenient position at the back of the camera as shown in Fig. 11. Four lenses are available on the lens turret ranging from 35mm to 100mm in focal length.

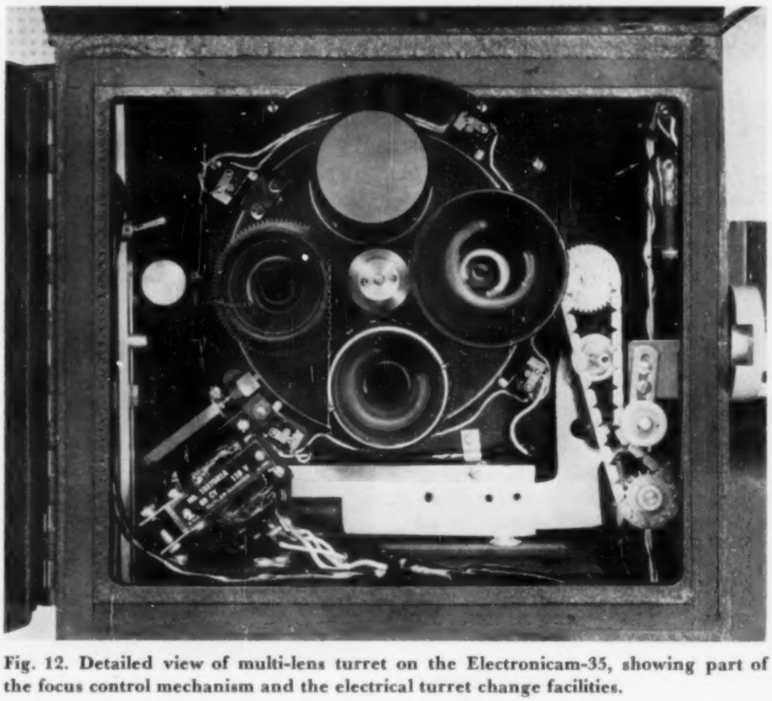

Fig. 12. Detailed view of multi-lens turret on the Electronicam-35, showing part of the focus control mechanism and the electrical turret change facilities.

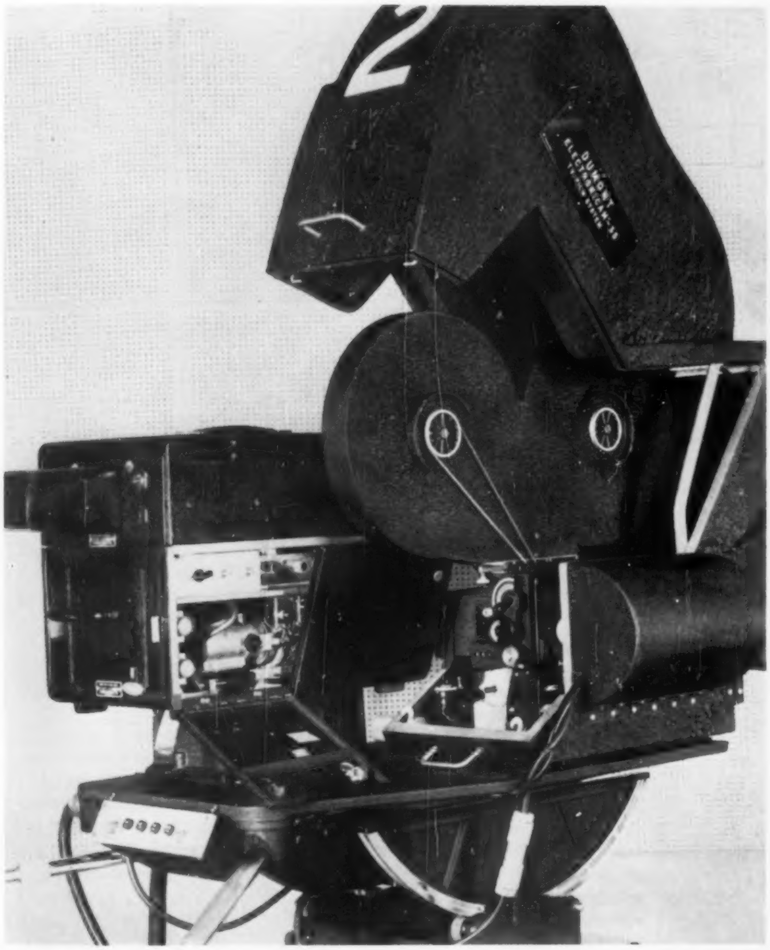

Fig. 13. The Electronicam-35 with blimp open in the film-loading position, showing variable shutter control, 2000-ft magazine and other features of the modified and adapted professional Mitchell mechanism.

Figure 12 shows some of the mechanical details on the lens turret including the remote focussing mechanism as well as the microswitches and other electrical controls for turret change.

In Fig. 13 the blimp is open in the position which permits loading of the camera. A 2000-ft magazine provides 22 min of continuous shooting with standard stock and approximately 30 min of shooting using Du Pont Cronar base stock. Exposure control can be independently adjusted within limits in the motion-picture mechanism by the conventional variable-shutter mechanism of the professional Mitchell camera. In addition to the footage indicator of each camera there are remote control-room repeater footage indicators for all cameras.

The apparatus is designed to provide convenient access to the film-loading area of the professional Mitchell 35mm camera as shown in Fig. 14. Loop protective microswitches as well as buckle plate protective circuits are included in this design. Film-marking bloop lights and the necessary operating facilities for these controls are provided for synchronization marking of the several cameras on the stage as well as the teletranscription recording and the soundtrack.

Figure 15 shows the control room facilities for the Electronicam system.

Control-Room Facilities

The control room contains primarily the normal facilities used by a television studio. Figure 15 is such a control room used in recording a color program on film. The several monitors provide pictures from each of the cameras continuously during the shooting. An additional monitor shows the selected signal for line feed at a given time. The director can thus talk with the crew and instruct the cameramen on setup of new shots while the shooting is in progress. The video switcher then, upon instruction, selects the desired shots which are fed to the air if simulcast is desired and to the transcription recording for later editing use.

Figure 16 shows the control-room video-switching panel which permits laps, fades, dissolves, etc., as well as sharp cuts from one camera to another. These editing indications are duly recorded on the teletranscription and can then be matched in the cutting room and printing process to prepare the final released film. The final film, of course, makes no direct use of the teletranscription for subject matter but calls upon the high-quality film being exposed continuously in the several cameras on the stage.

In order that the television pictures be most effective as a control of high-resolution film, the television cameras and other video circuits have been particularly refined. The circuits are under control of the operator and therefore need not be limited to 6-mc channels as in the case of television broadcasting. Consequently, the wide video bandwidths available are used to their fullest to insure the sharpest possible focus to facilitate the cameramen's adjustment of

Fig. 15. Control-room facilities for the system.

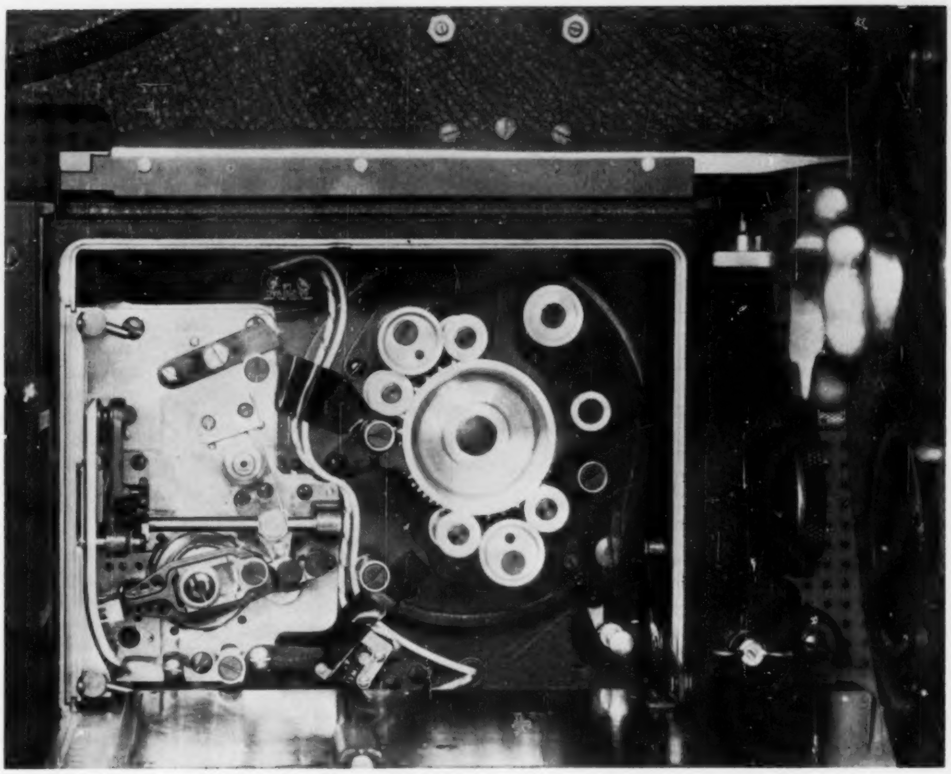

Fig. 14. Film-loading area of the Electronicam-35, showing the professional Mitchell movement and the electric safety interlock circuits.

the lenses during ad-lib shooting of programs. No tabs or marks on the floor are necessary. Rehearsals and actual shooting may be done relatively rapidly and program spontaneity is thus much improved. The electronic facilities are readily modified to accommodate wide-screen principles of film shooting since the area and aspect ratio of television pickup may be readily adjusted by simple scanning modifications in the television system. The electronic gear is therefore simply adapted to the special motion-picture recording apparatus used for these wide-screen processes. Apparatus illustrated in the pictures here provide the conventional theater aspect ratio on both 16mm and 35mm film.

In the control room the usual television apparatus is supplemented by one additional control panel (Fig. 17) which provides the necessary individual or ganged switches for bloop synchronizing marking and for motor control of the film drive in the several cameras. Figure 18 illustrates a teletranscription recording unit equipped with 1200 ft of 16mm film which photographs a continuous ½-hour program from the face of a 7-in. cathode-ray tube. Video amplifiers and monitor control circuits permit gamma balance of either a positive or negative polarity picture on a cathode-ray tube to insure recording quality.

Figure 19 shows a four-gang 16mm editing machine on which the synchronous films are lined up. The teletranscription cutting master film provides an easy means of determining the cutting points for combining the filmed product of the three continuously running cameras into the final release master film.

Fig. 16. Details of the video switching controls providing fades, laps, dissolves, etc., between cameras in the Electronicam System.

Production Practices

The Electronicam System makes available, to the entire production team, a new creative tool. Mental visualization and development of a production resulted in the story board approximation of what was desired as a final result on film. The talent and memory of the camera operator constituted the single factor responsible for the final interpretation of the creative effort of the production team.

The Electronicam System now permits the entire team to see as it shoots. It makes possible complete visual rehearsals without shooting a foot of film. The director can "dry run" entire scenes or sequences with the inclusion of all effects such as fades, dissolves, wipes, boxes, etc. These effects, developed electronically and available on the sys-

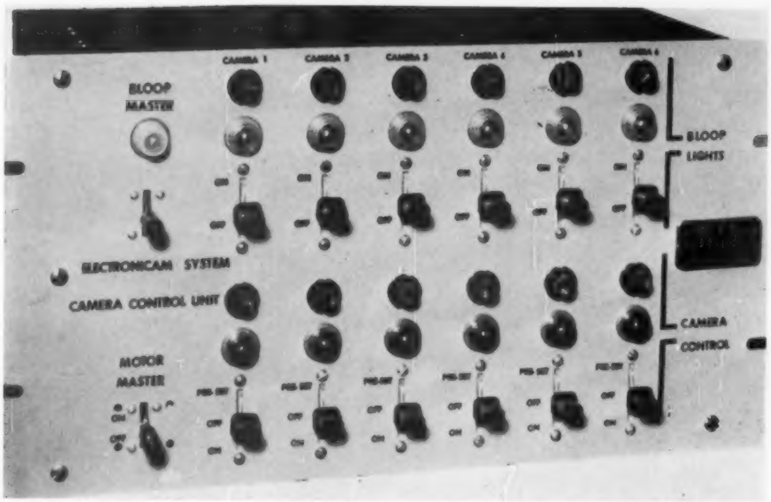

Fig. 17. Bloop and motor control panel for control-room operation of the film portion of the system.

tem's picture monitors, enable the director to develop tempo and pacing of a scene's playing to the dramatic split second of pay-off. As pointed out previously, the system utilizes multiple cameras operating continuously and covering the scene from all desired angles. The director during rehearsal and actual shooting "edits electronically" by calling for the camera recording the desired take. The selected camera is switched on cue to the "take monitor" which provides the complete production team with a scene-by-scene playing of a sequence. In the area of special effects, the electronic effects generator and matting amplifier make possible the shooting of all types of matte effects in easily accomplished registration.

During rehearsal or during the period of actual shooting the video recorder of the system can record on 16mm stock any or all scenes or sequences called for by the producer or director. This teletranscription of any production provides a complete composite that includes picture, sound and all effects (developed electronically) exactly as called for by the director. Instead of waiting days for a composite developed optically, the video recording is ready for screening as a "rush" in a very short time on the same day it is shot. This facet of the Electronicam System permits all involved in a production to evaluate their efforts before shooting decision is finalized. The video recording that is made at the time of final shooting provides an editing guide since it records all scene changes as well as the beginning and end of all effects that will be later printed, with standard optical practices. If the production staff approves, the video recording made at the time of the final shooting becomes the "editing guide" for cutting and is locked in sync with the negatives from the number of cameras used during production. If it is not approved, the complete footage shot continuously in all cameras provides ample protection footage for change of editing decision without the necessity of re-shooting.

The "ad lib" follow-focus feature includes a Hi "D" electronic picture in the camera's video viewfinder to provide "on-the-nose focus" at all times during shooting. It is no longer necessary to tape each take and restrict talent to strictly limited playing areas. In the future when a player misses his or her "mark" the take will not be labeled "NG" as the operator will easily and simply follow the action "in focus."

During recent shootings of the *Jackie Gleason Show* this feature of the system was dramatically illustrated. On one occasion, due to a speeding up of playing time, it was noted at a point beyond the half-way mark that the show was running short by some two minutes. The Gleason company "ad libbed" business and dialogue during the take, after receiving a cue indicating the necessity for a stretch. The camera operators had no idea of the business coming up, yet with the follow-focus feature easily and accurately followed the new and unrehearsed action. Incidentally, the Gleason Show is shot before a live audience of 1200 in the average shooting time of 37 min. The continuous multiple-camera shooting techniques permit the performer to develop character, pacing, mood, and dramatic intensity in a single uninterrupted take. In the field of comedy this continuous complete sequence "take" permits the comedian to build his business and reach the pay-off in a natural manner that greatly accentuates the

Fig. 18. Teletranscription facilities.

desired results expected from his material.

With this system, the enormous amount of costly time now taken in setting up cameras on a scene-to-scene basis can be eliminated in favor of television techniques which feature continuity of action. The setup time, especially in spectacle films where large groups of performers are filmed, can be particularly costly. Directors now spend hours setting up cameras and adjusting and changing their positions for a scene which may last only a minute. Through the use of a battery of monitors and an intercom system, every camera can be set up from a central point, and the directors can have an exact picture of what the camera "sees" not only in advance, but while the camera is actually shooting, thereby greatly reducing the overall production time

The Electronicam System helps solve lighting problems. The lighting director can evaluate the lighting in advance, follow it through rehearsals, and make appropriate adjustments and changes before a single foot of film is exposed. This instantaneous television viewing adds a new dimension for the producer so that he is able to feel the "mood" of the scene in accordance with his desires.

Pickup units are mobile. In the production of films for television or theater showings, the director gets the same camera mobility as in a live television broadcast, the same monitoring facilities, and a high-quality film print as the end result.

The Electronicam System does not interfere with, but rather supplements, already tried and proven techniques used in movie making in the fields of direction, production, lighting, and sound recording.

The techniques of this system will have a far-reaching effect not only in television broadcasting but in all areas of endeavor where action or subject matter must be recorded on motion-picture film. A great deal must be learned relative to its most efficient use in various fields. Extensive experience background has already been gained as a result of the commercial use of the equipment by the Allen B. Du Mont Laboratories.

Relation to Color Television

An interesting aspect of this method of program recording is its possible impact on color-television broadcasting. Present live-color practice is to use several cameras. It is difficult to match properly the color response of these several cameras compared with one another. Even within one camera three separate image-orthicon tubes are used; these have differing transfer characteristics which result in compromise transfer and gamma balance for the respective channels, red, green and blue. Furthermore, the difficulty of maintaining the registration of electronic scan on these three tubes tends to produce a transmission of erratic contrast balance which is subject to some color fringe under the best of conditions.

Fig. 19. Multiple synchronous cutting and editing facilities for the Electronicam System.

Considering several Electronicam units loaded with color film, we have quite comparable color-taking characteristics from camera to camera since these characteristics are dependent upon carefully controlled emulsions which are uniform in the present state of the art. The Electronicam using one lens provides no registration problem of the colors since color processes available from the several laboratories supplying color film are quite free of registry errors in the emulsion itself.

These films then combined with the televising characteristics of the Du Mont Cinecon can convert the filmed record into color-television broadcast signals of high quality still free of any registration difficulty since the Cinecon has a single lens and splits the color channels behind the film.

It will be interesting to observe the trend of this team of Electronicam and Cinecon as a color-television tool in comparison with the other promises of magnetic-tape recording and other methods of direct recording of color from color cathode-ray tubes.

Direct live color pickup is difficult to control where very wide ranges of brightnesses are encountered, for example, in outdoor pickups such as the recent World Series baseball games. Color film can readily be used under such circumstances. Once this film record is completed, then proper gamma compression and expansion circuitry can be applied with the Cinecon and its video circuits to make the best use of such wide latitudes of scene lighting to provide a good broadcast. Live telecasting may be essential on newsworthy events such as the World Series, but this intermediate Electronicam method might have superior uses for pickups which are worthy of delayed broadcast. We should point out that the Electronicam may be the answer to the need for a brightness-range-compressor which to date has not been achieved in the live television gear. This brightness compression would consist of two parts: (1) the compression characteristics of the film itself; and (2) the further compression characteristics available with electronic gamma control.

A film chain can perhaps be more readily controlled as to gamma transfer characteristics than would be practical of control when using several live cameras in succession in the field.

The authors wish to express particular appreciation for the able assistance in the development of this equipment to Robert T. Cavanagh, G. Richard Tingley, Jesse Haines, Donald Pounds, and others of the Du Mont Research Laboratories staff.

Both 16mm and 35mm films were displayed at the Lake Placid Convention but cannot be portrayed here. These films illustrated black-and-white and color subject matter recorded by the Electronicam TV-Film System. In addition, the motion pictures illustrate the actual control and operating methods employed in this type of motion-picture shooting.

Discussion

Frank Gillette (General Precision Laboratory): In both the systems I think you have three-lens turrets with a field lens behind each for the television channel. In other systems of that nature where various objective lenses are used it is common to switch the field lens, in order to get best distribution of light. Do you do this?

Dr. Goldsmith: We simplify the system so only one lens need be changed when going from a given objective lens to a second objective lens. Only the objective lenses are switched. There is no switching of the field lenses because we have an aerial plane which is the same size and shape and in the same relative position as the film plane. We simply pass that focused image on to a new focused position so it is at the same framing and the same focus as the film plane no matter what objective lens is used, in the geometry we use.

Dr. Gillette: This is also true in the RCA color camera but there they still find it necessary to shift the field lens in order to obtain best distribution at the image orthicon.

Dr. Goldsmith: Here, we want the film to get an excellent quality reproduction so it is treated

with the highest respect in the optical design. But remember the television picture is simply a view-finding tool. It is not necessary for that picture to have all possible refinements. But, we would note that the television picture is excellent. We have excellent high-frequency response there and the pictures that come out of this system are more than adequate by a wide margin for the editing purposes to which we put them—for the viewfinder, the cameraman, the control room staff and the transcription. They are thoroughly comparable to broadcasting signals that we have today. We have not been broadcasting these signals on a simulcast basis but they could be used for that purpose.

Reid H. Ray (*Reid H. Ray Film Industries*): What is the approximate weight of the two units, the motion-picture camera and your television camera? Both 16mm and 35mm individually?

Dr. Goldsmith: As you noticed in the pictures, there was no attempt made in this particular apparatus to provide an optimum design of the electronic gear nor to compact the film mechanism and its sound blimping for best field portability. These are larger than necessary and our research laboratory is taking steps to eliminate that. I don't know the exact weight of the 16mm but it is about 200 lb, that is the part that comes up above the panning head. I'm not talking about the dolly because a variety of dollies are being used. The 35mm machine with its 2000-ft reel loaded comes close to 400 lb.

Henry Roger (*Rolab Laboratories*): Are all pictures taken at 24 or 30 frames per second?

Dr. Goldsmith: The pictures in both these units are currently being recorded at the standard rate of 24 per sec. But by using a different motor drive the rate could be changed, particularly on the second model, the 35mm machine, where the light continues to go to both paths. Whether the film camera is running or not cannot be determined by looking at the television picture because there is continuous light in that path. This mechanism can be used for high-speed work as well as for low-speed work at rates other than the standard 24 frames.

Mauro Zambuto (*Trans-Films*): In producing these pictures did you notice any limitation to the wide variety of lighting that is possible when you use a single camera and split the action in several parts because of the fact that now you're using three cameras and you have to strike a lighting that is more or less optimum for all of them?

Dr. Goldsmith: There is a little different philosophy of lighting. The easiest way is to have general lighting and to shoot without much change of lighting except from one scene to the next. But with an Izenour Control Board and the rapid preset lighting conditions that we have in our studios in New York we can cue lighting changes for dramatic effects as quickly as we switch cameras. At the present time we aren't using too much iris control of a remote nature on this, to free the cameraman of this film worry. He's doing a television job. But as you go to a wider variety of programs with more dramatic effects in lighting there would be a necessity for some servo control of the exposure level adjustments in the camera. We now use a 5.6 or a 6.3 stop, where our depth of focus is very good, and the TV is a very good means of insuring that you're right in the middle of that focal range for the recording.

Color Video Switching

By W. B. WHALLEY
and R. S. O'BRIEN

In color video switching equipment, the nature of the encoded signal requires that particular care be taken to achieve, over the frequency band, constant amplitude and delay, low differential gain and phase, and low crosstalk. Furthermore, performance must be independent of the number of output circuits connected to a particular input bus. Equipment meeting these requirements has been operating in CBS color-television studios in New York and Hollywood since August 1954. The objectives were achieved by adding back-contact loading to maintain constant capacitance on each input bus, by compensating this capacitance with loading coils in each input bus, by reducing capacitance coupling through contacts, and by minimizing distortion in output coupling amplifiers.

One of the essential requirements of a television studio or master control center is a control device which can rapidly switch any one of several video signals to one or more output circuits. Every live or film camera signal must be transmitted through such a studio switching system, then, usually, through a master control switcher and, often, through additional video signal selectors in the more involved program originations. These omnipresent video switching facilities must be capable of rapidly changing video signal routing combinations without introducing noticeable degradation in signal quality under any conditions of operation.

Because of the rigorous requirements of the FCC-approved NTSC color system, the design specifications for a satisfactory color video switching unit become quite critical. The rather vulnerable location of the chrominance portion of an encoded color signal at the upper end of the video band requires that uniform amplitude and phase-versus-frequency response be carefully maintained. As derived from the FCC Standards, the overall transmission system for color signals must have amplitude response uniform within ± 2 db from 15.7 kc to 4.2 mc. This covers the entire system, including studio and master control equipment, telephone company circuits, the transcontinental network and the television transmitter. A reasonable portion of this amplitude-response tolerance which can be allocated for a video switcher may be taken as 0.3 db. Similarly, the switcher portion of phase delay should be held within ± 0.02 μsec; the differential gain below 1% and the differential phase below 0.5°. Crosstalk isolation between channels for any switching combination should exceed 50 db at frequencies up to 5 mc.

All methods of switching video signals, whether by switch contacts, relays, tubes or crystal diodes, involve equipment having distributed capacitance and inductance. Consider, for example, the commercially available video switching units. When an output circuit is connected to one of the input lines, a considerable capacitive load is placed in parallel with the line termination. This load consists of the switch capacitance to ground plus that of the output bus and of the coupling tube input circuit. As the required number of input circuits increases, the switch capacitive load increases, and because of increasing physical size, the length of each *output* bus increases. Furthermore, as an output bus increases in length, in combination with the capacitive loading, it may reach a sufficient electrical length to give "stub" loading of an input line. These conditions can readily result in a serious change in both chrominance phase and amplitude-frequency response.

To retain the reliable and relatively trouble-free direct contact feature of the relay cross-bar system, refinements have been applied to commercially available equipment in present CBS-TV color

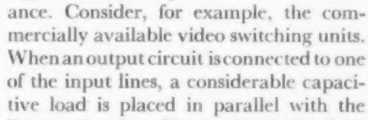

Fig. 1. Schematic of a 75-ohm coaxial line having the shunt capacitance C in parallel with the 75-ohm termination. When C reaches 20.7 μμf the phase angle at 3.58 mc (the color subcarrier frequency) shifts one degree.

CBS Television Report No. E-3014-A, September 19, 1955: Engineering Dept., CBS Television, Columbia Broadcasting System, Inc., 485 Madison Ave., New York 22.
(This contribution was received on October 5, 1955.)

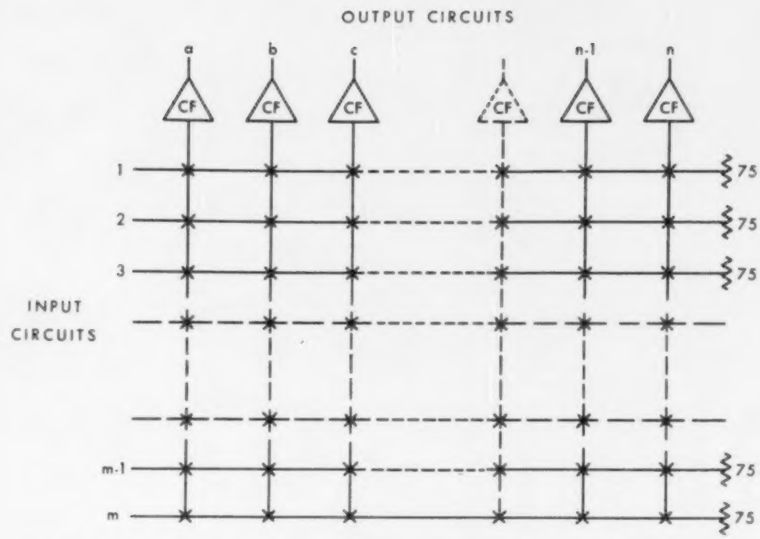

Fig. 2. Basic matrix of a video switcher having m terminated input circuits and n output circuits. Each output bus is connected through a high input impedance cathode follower, CF.

installations.* The steps taken include: first, addition of back contacts and capacitors on video relays to maintain the equivalent of the total output bus capacitance across each input bus, whether the relay is open or closed; second, to compensate for this constant value of capacitance, loading coils are introduced in the input busses, converting each bus to a lumped constant line; third, care is taken in output coupling amplifier design to reduce capacitance and minimize differential phase and gain; finally, crosstalk is reduced by provision of extremely low capacity coupling through open relay contacts. The detail design considerations and a typical installation are described herein.

* It may be noted that other arrangements might be used. For example, each switching junction point might be isolated by a vacuum tube—requiring a rather tedious and frequent gain balance adjustment. Another suggestion would be to handle each color separately before encoding, but the triplicity of relays and fader amplifiers makes this cumbersome and introduces the problem of maintaining tri-channel gain balance.

Effect of Capacitance on Chrominance Phase

In order to adhere to RETMA television equipment standards it is necessary to employ 75-ohm nominal impedance input lines. With a 75-ohm line terminated accurately in a resistor or complex termination (dependent upon the length of line†) and fed with a 75-ohm output impedance video amplifier, the change in transmission with shunt capacitance may be calculated as set forth below.

At frequencies above 0.5 mc, the line impedance becomes quite closely 75 ohms, hence Fig. 1 shows the shunt capacitance in parallel with the 75-ohm line termination. Since the line is assumed terminated at both ends, the net resistive value is 37.5 ohms.

† W. B. Whalley, "Color-television coaxial cable termination and equalization," *Jour. SMPTE, 64:* 8–12, Jan. 1955.

The change in phase angle α resulting from a circuit configuration of this type is:

$$\alpha = \tan^{-1} RC\omega \qquad (1)$$

$$\text{or } C = \frac{1}{R\omega} (\tan \alpha) \qquad (2)$$

At the color subcarrier frequency of 3.58 mc, a change in α of 1° represents a change in hue of approximately one half of the minimum perceptible amount. Substituting $R = 37.5$ ohms, $\omega = 2\pi \times 3.58 \times 10^6$ radians, and $\alpha = 1°$,

$$C = \frac{1.0 \tan 1°}{37.5 \times 2\pi \times 3.58 \times 10^6} \qquad (3)$$

$$= 20.7\ \mu\mu f.$$

Accordingly, video switching circuits must be designed so as to limit any *change* in capacitance during switching to less than 20 $\mu\mu$f.

Circuit Design

Figure 2 shows the basic matrix of a video switching unit having m input lines each terminated in 75 ohms, and n output circuits, each coupled to an output bus through a cathode follower CF. The total capacitance which is added to each input line increases as the number (n) of output circuits increase. Also, as m increases, the capacitance of each output bus increases.

In some relay-operated switching units, each crossover point may employ two relays designated as A and B relays. Two relay busses working through an output transfer relay are used to provide more rapid switching between input circuits and to give minimum signal disturbance during switching,

The capacitance C_o of each output bus is:

$$C_o = m(C_1 + C_2) + C_3 \qquad (4)$$

where m is the number of input circuits, C_1 is the open circuit *output* capacitance of each switch or relay (A *or* B), C_2 is the capacitance of each interconnecting section of an output bus (A *or* B), C_3 is the input capacitance of the cathode follower (including connector, if one is used). The first approach to reducing the undesirable effect of the large capacitance of each output bus was to consider the addition of loading coils between each pair of crossover points on each input and output line. This would convert each circuit into an artificial transmission line with the small capacitance of a *single* switch or relay contact between each loading coil. This would be quite satisfactory insofar as the input lines are concerned. Unfortunately, however, the effective *length* of each output bus may become so great as to have a major effect upon the amplitude-frequency response.

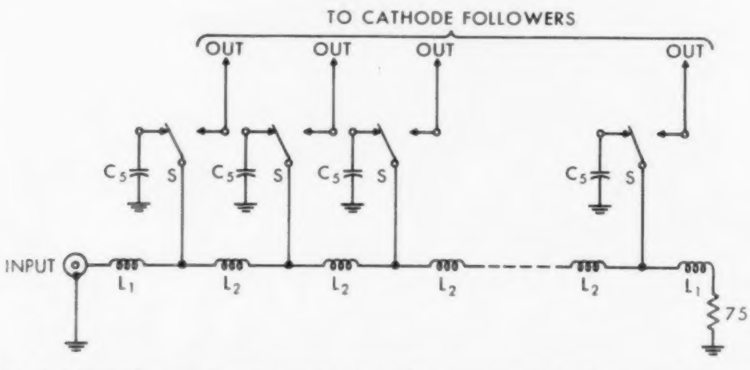

Fig. 3. Schematic of each compensated input line showing the inductances L_1 and L_2 with extra switching sections S and capacitors C_5. C_5 with L_1 and L_2 form a constant impedance artificial 75-ohm line.

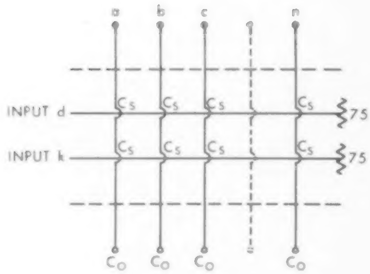

Figure 4A

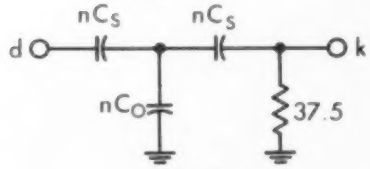

Figure 4B

Fig. 4. Matrix (4A) and equivalent circuit (4B) for analyzing the "crosstalk" between any two input circuits d and k for the condition in which all switch contacts are open. C_s is the open circuit capacitance between input and output terminals of one switch and C_o is the total capacitance of each output bus.

The physical length of each output bus increases with the number of input circuits and with the lead length to the cathode follower grid. Thus, each bus becomes a "stub" line coupled to an input line. The worst conditions occur when lines l or m are switched to an output circuit, corresponding respectively to connection at the receiving or sending ends of the stub.

The end loading impedance Z_{oe} of such a stub is:

$$Z_{oe} = -jZ_o \cot \theta \qquad (5)$$

where Z_{oe} is the end loading of an *open-circuit* line, Z_o is the iterative impedance of the line, and θ is the effective electrical length in degrees. Adding loading coils to any output bus increases the electrical length θ as rapidly as Z_o increases. The product $Z_o \cot \theta$ will, therefore, remain almost constant and no appreciable decrease in Z_{oe} will take place. Hence, there would be no improvement gained by adding coils to the *output* lines.

The present design approach is to keep each output bus as short as possible, the capacitance at the output side of each switch or relay contact as small as possible, and to have the cathode follower connected near the center of the output bus. Since Z_{oe} is a negative imaginary quantity, each bus is treated as a lumped capacitance, to be compensated for by loading coils appropriately located in each input line. Next, it is necessary to compensate for the discontinuity when a switch opens, removing the output circuit capacitance. The method used is shown in Fig. 3, where an additional switch contact adds a capacitance C_s equal to C_o [see Eq. (2)] when the output circuit is opened. Thus each input circuit remains a constant impedance artificial 75-ohm line whether or not the output circuit is closed.

The value of inductance, L_2, for correct compensation of the capacitance C_o is:

$$L_2 = 0.00564C_o = 2L_1 \qquad (6)$$

By careful adjustment of L_1 and L_2 (see Fig. 3), and correct choice of C_s, amplitude-frequency response constant within 0.3 db to 4.5 mc and within 0.5 db to 6 mc has been obtained for any switching condition. Yet this inductive compensation does not involve any increase in the physical size of the switching assembly.

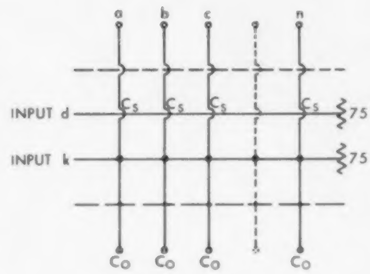

Figure 5A

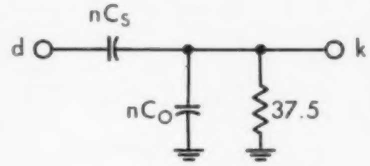

Figure 5B

Fig. 5. Matrix (5A) and equivalent circuit (5B) for analyzing the "crosstalk" between any two input circuits d and k for the condition in which all n switches are closed to one input circuit k and none are closed to input circuit d. C_s is the open circuit capacitance between input and output terminals of one switch and C_o is the total capacitance of each output bus.

Constancy of Delay With Frequency

Each compensated line forms an artificial transmission line, whose cutoff frequency f_c is:

$$f_c = \frac{1}{\pi\sqrt{L_2C_o}} \qquad (7)$$

where C_o is the quantity shown in equation (4) and L_2 is shown in Eq. (6).

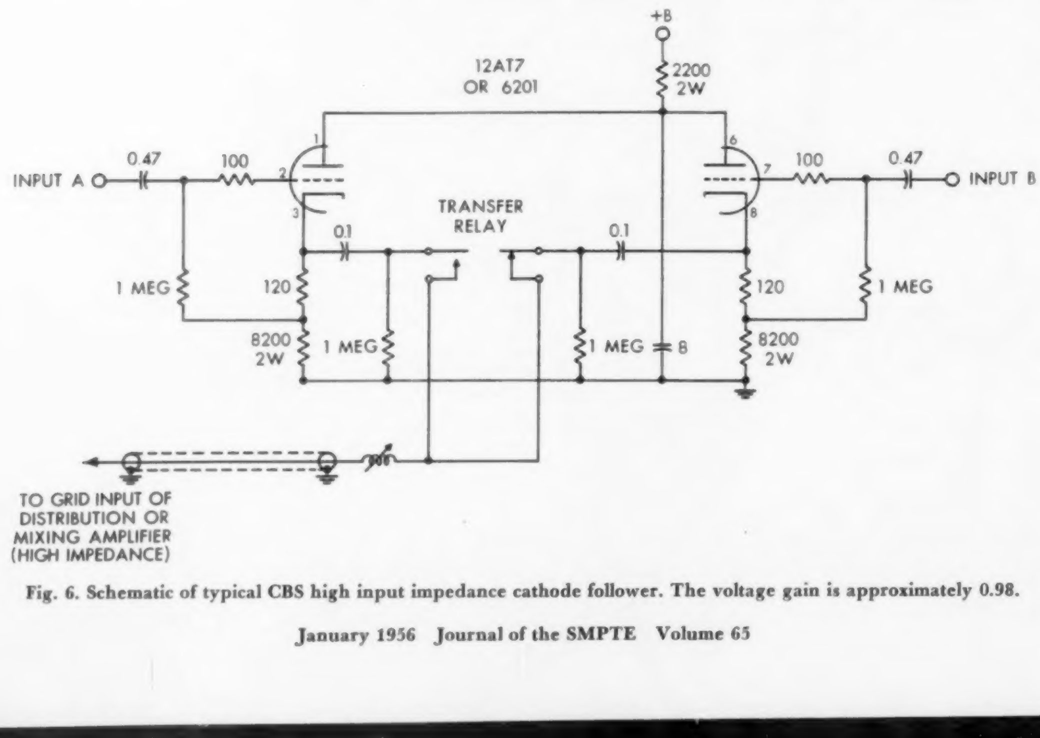

Fig. 6. Schematic of typical CBS high input impedance cathode follower. The voltage gain is approximately 0.98.

When C_o is sufficiently small, and the cutoff frequency is over 35 mc, the variation in delay between 15.7 kc and 3.58 mc is so small as to be negligible and well within the required tolerance of 0.02 μsec.

For one section of a low-pass filter of the "constant-K" type, the phase angle β at any frequency f is:

$$\beta = 2 \sin^{-1}\left(\frac{f}{f_c}\right) \text{ (in degrees)} \qquad (8)$$

The delay T at any frequency f is:

$$T = \frac{1000}{360}\frac{\beta}{f} = \frac{5.55}{f}\sin^{-1}\left(\frac{f}{f_c}\right) \mu\text{sec} \qquad (9)$$

where β is in degrees and f in kilocycles.

As an example, if C_o = 120 $\mu\mu$f, L_2 = .676 μh; then from Eq. (7), f_c = 35.3 mc. The change in delay between 0.1 mc and 7.0 mc is calculated as follows:

T at 0.1 mc is

$$\frac{5.55}{100}\sin^{-1}\left(\frac{0.1}{35.3}\right) = 0.0090021$$

T at 7.0 mc is

$$\frac{5.55}{7000}\sin^{-1}\left(\frac{7}{35.3}\right) = 0.0090682$$

The difference in time is less than 0.00007 μsec. Hence, for the aforementioned limit of 0.02 μsec, some 300 sections of L_2 and C_o, corresponding to a switching panel with 300 output circuits, would have satisfactory delay characteristics to more than twice the color subcarrier frequency.

Cathode Follower Design, Differential Gain and Phase

Each output bus is coupled to the external load, which may be a distribution amplifier or mixing amplifier, by means of a cathode follower. It is important to choose a circuit with low input capacitance and high gain. There should also be low differential gain and phase and provision for power failure. Figure 6 is the schematic of a double cathode follower circuit, which employs an adjustable inductance in the output lead to compensate for the capacitance of the output cable and grid circuit of the next amplifier.

Choosing a relatively large value of cathode resistance R_K = 8200 ohms, the tube has a gain of about 0.98, and the input capacitance is reduced, measuring only 7 $\mu\mu$f for each completely assembled grid circuit.

The high value of R_K and the high impedance of the load result in a very *low* ratio of signal current to plate current (close "following"), hence the *differential gain* is negligible, measuring less than 0.1%. Similarly, the cathode follower input grid capacitance remains constant with grid swing and the *differential phase* is also negligible, measuring less than 0.1°.

Crosstalk Isolation

Careful design is essential in all types of video switching units to keep crosstalk at a minimum. In color television this is of particular importance because of the relatively large amount of energy in the higher frequency end of the band. Each switch or relay contact has some associated small value of open circuit capacitance, C_8, between input and output terminals. The value of C_8 depends upon the shape of the contacts and supporting fingers and upon the degree of shielding between the input and output terminals. Mounting the switches or relays through suitable openings in a conducting panel, so that all the input circuit lines are on one side and the output buses on the other side of the panel, much reduces the capacitive coupling. Given a well designed low open-circuit-capacitance relay the crosstalk between two input circuits may be considered for two typical conditions, the first (see Fig. 4) when all contacts are open, the second (see Fig. 5) when all the output buses are closed to one of the input circuits.

In condition 1, the undesirable signal coupling is from input "d" through each open cirucit capacitance C_8 to an output bus, from the output bus through a similar capacitance Cs to the "k" input circuit. It is readily seen that the cross coupling increases directly with n.

In condition 2, shown in Fig. 5, the undesirable signal coupling is from input "d" directly through each capacitance C_8 to the line "k," also increasing directly with n.

Comparing the equivalent circuit Fig. 4B, for condition 1 with the equivalent circuit Fig. 5B, for condition 2, it may readily be seen that condition 1 provides the greater isolation. This is caused by the additional attenuation of the capacitive divider section composed of nC_8 and nC_o, absent from condition 2. Hence, condition 2 has the greatest undesired coupling and the crosstalk magnitude may be calculated as follows. The voltage E_d developed across input line d is:

$$E_d = \left(\frac{37.5}{37.5 \; \frac{-j}{nC_8\omega}}\right)E_k \qquad (10)$$

For any condition where the magnitude of the capacitive reactance is equal to or greater than 100 times the cable impedance (37.5 ohms), i.e. when

$$\left|\frac{1}{nC_8\omega}\right| \geq 3750 \text{ ohms,}$$

the equation simplifies to:

$$\frac{E_d}{E_k} = 37.5nC_8\omega = \phi \qquad (11)$$

$$\text{or } nC_8 = \frac{1}{37.5}\frac{\phi}{\omega}\mu\mu\text{ f.} \qquad (12)$$

As an example, for the color subcarrier frequency f = 3.58 mc and for ϕ = 0.001 (60 db isolation),

$$nC_8 = \frac{1}{37.5}\left(\frac{0.001}{2\pi \times 3.58 \times 10^6}\right) = 1.18 \;\mu\mu\text{f.}$$

This shows that the open-circuit capacitance C_8 of each relay must not exceed 0.118 $\mu\mu$f if *ten* output circuits and 60-db isolation at 3.58 mc are required.

Measurements

Inductance Adjustments: While progressively adjusting the loading coils L_1 and L_2 (Fig. 3) for the most uniform amplitude-frequency response, the resonant frequency of each coil and its associated capacitor C_5 was checked with a grid-dip meter to keep the resonant frequency at the same value and, therefore, to assure the same value of inductance for each coil.

Crosstalk: Crosstalk may be measured by supplying a suitable signal from a sweep generator to one input circuit and measuring the associated signal level at the termination of another input circuit, with all video contacts open on the first input and all closed on the second. With a wide-band high gain amplifier and calibrated oscilloscope, the ratio of voltages at each selected frequency may be obtained.

Conclusion

The rigorous requirements of the FCC-approved NTSC color television system make it necessary to greatly refine the electrical design and physical arrangement of the video circuits of studio switching units. By adding suitable loading coils to each input circuit and switching the associated compensating capacitors through an extra contact on each switch position, uniform amplitude-frequency response has been obtained. The use of high value cathode resistors and series compensating coils provides cathode follower output circuits having negligible differential gain and differential phase. Crosstalk is kept low by using relays with low open-circuit coupling capacitance and thorough shielding between the input and output circuits.

Relay switching units with these design features have been in use in the CBS color television studios at New York and Hollywood since August 1954, and transmission tolerances well within the NTSC specifications have been achieved.

Acknowledgment

The authors wish to acknowledge the encouragement and helpful suggestions offered by Howard A. Chinn, Chief Audio-Video Engineer, K. B. Benson and Price Fish, all of CBS Television.

Educational Television

A session of three papers held on October 7, 1955, at the Society's Convention at Lake Placid, N.Y. The discussion for the three papers follows the third paper.

Are We Educating by Television?

By GERTRUDE G. BRODERICK

The answer to the general question, "Are we educating by television?" is a definite "yes" despite much skeptical insistence to the contrary. As an educator, I should be standing before you with my head bowed in shame if the answer were anything else. Educators today have no choice in the matter, and we would be derelict in our duty if we failed to accept our fair share of responsibility to see to it that this newest medium of mass communication is used for something more than entertainment.

Perhaps a sound reason can best be established if we examine a few statistics. For example, the director of research and planning for the National Broadcasting Co., on July 1, 1955, announced that as of that date, television installations in this country had reached a new high of 36,477,000 sets. This represents an increase of 377,000 during June, and 2,661,000 since January 1, or an average well over 400,000 a month.

In a recent speech before a Washington group, Federal Communications Commissioner Rosel Hyde revealed that approximately 75% of the families in the United States now have access to a television set, with a further estimate that some degree of television reception is presently available to more than 90% of the population.

Juvenile Viewing Habits

Now let us examine some of the figures on viewing habits, for they too are quite extraordinary. Testimony presented before the Senate Subcommittee to Investigate Juvenile Delinquency revealed that children spend 2 to 3 hours a day before a television screen, or about 15 hours a week. Other estimates suggest a comparable record for adults. These figures are all the more significant when we contrast them with the estimated time spent on other media of communication: newspapers, magazines and motion pictures.

Estimates here indicate that the average American spends approximately 30 minutes a day with his newspaper; 16 minutes a day on his magazine; and about an hour a week attending the movies. This is little more than 5 hours a week for all three—only about one-third the time spent on television.

When we contrast the estimated viewing time with the time a child spends in school, we again are struck with the depth of television's permeation. A child spends $5\frac{1}{2}$ hours in school, 5 days a week, for approximately 36 weeks. At the same time he spends 2 to 3 hours each day, 7 days a week, for 52 weeks viewing his favorite television programs.

Isn't it obvious, therefore, that first as citizens, and then as educators, we both have a stake in and an obligation toward this medium which can exert such an influence over our own thoughts, the thoughts of our children, and of our neighbors?

Today's Education Problems

A brief examination of some of the pressing problems in education such as, for example, the figures released just a few months ago by the U. S. Commissioner of Education, shows that public and private schools in the continental United States opened with 39,557,000 students, an increase of 1,657,000 over that of a year ago. The Commissioner further pointed out that this is the 11th consecutive year of increased total enrollments, and forecasts for the next 10 years through 1965 indicate substantial increases for each year ahead. Think of what this involves in terms of buildings alone!

If we are even partially successful in meeting the building needs of our school population at all levels, we shall witness the greatest school building construction program in the history of American education in a comparable period. In higher education, it has been estimated that, if past ratios hold, we shall need as much building space in the next 25 years as we have acquired in the past 200. Even if we reduce the comparison to the years of greatest development—namely 1900 to 1955—we still have a task of a magnitude which has not yet penetrated public or professional understanding.

Perhaps we ought to ask the professional broadcasters to leave their transmitters and studios, and work with the general fraternity of educators, in an effort really to take measure of the new enrollment load. We talk about it, statistically wring our hands, raise some questions, but so far we have been dealing largely with abstractions. There is danger that we shall not really awaken to what is ahead until the enrollment is upon us, and we then shall frantically erect makeshifts—second rate at best—as we did after World War II. Fortunately we still have a little time to experiment with new ideas, new methods, new organization.

It is in this setting that we must take the long look at educational broadcasting and see to it that it is brought from the periphery to the center of current practices. The film, the radio, and television must become major helps instead of incidental ones, if the critical challenges facing us in education today are to be met.

Quality in education, at all levels, is bound to suffer unless we recruit more effectively for teaching and plan more realistically to find new methods of teaching.

In the presence of the almost overwhelming problem of teacher supply for the load ahead, the present academic indifference to the use of radio and television as teaching tools is difficult to understand. The traditional apathy of college teachers with reference to teacher recruitment and preparation was not important as long as we had enough reasonably good teachers to go around. Now, however, we cannot indulge in the luxury of indifference. In television we have a great new force in communication. To ignore its potential for teaching is neither scholarly, nor professional, nor sensible in the presence of the overwhelming load.

It is not meant to imply here that all teachers should aspire to do their teaching job before a television camera. The television teacher must be endowed

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with certain gifts of personality as well as a thorough knowledge of his subject in order to project those gifts to his audiences. Experienced producers will testify that the popular classroom teacher may be a "dud" on television; and conversely, that a previously not-noticed person may turn out to be most effective before the camera.

Teaching to me has one profound purpose: to take the vitality of what has gone before and make it a part of the reality of today and the promise of tomorrow.

With stimuli for both eye and ear, with the advantage of immediacy, with the sense of intimate participation, television can broaden horizons, sharpen awareness of events and ideas and encourage discussion at home as well as in the classroom. An authority in a given field can speak once on television with perhaps more effect than he can by many appearances before small groups. Scientific demonstrations, normally available only for close study by a small group, can be done very skillfully and effectively for large groups of viewers before the camera. Television can complement classroom instruction by placing at the disposal of every school, large or small, all the resources of our great libraries and museums.

The effectiveness of the teacher in broadcasting would be less important without another element in the new exploration. I refer to the large numbers of people who are eager for serious learning experience and who are anxious to undertake systematic study with the help of the teacher-broadcaster.

The Case of a Pioneer

There are many examples to demonstrate the point. In the field of higher education we might begin with one of the pioneers, Western Reserve University in Cleveland. At the latest count, their extension program on television was seen every day by 10,000 to 30,000 viewers, hundreds of whom registered for credit. Subject areas have included courses in child psychology, American government, biology, economics, history, sociology, comparative literature, speech and the arts.

As early as 1942 this university's drama department started experimenting with television, using only dummy cameras. In 1947 Western Reserve staged its first live program, and in 1950 it began a series of half-hour programs on Sunday afternoons. Apparently the audiences liked what they saw, and in the course of the following year, a daily half-hour program on a special subject was presented. The success of this experiment encouraged Western Reserve to approve the offering of regular university courses for television home study, with or without credit. That was in the fall of 1951, and the program has been progressing ever since.

Students may register for the regular telecourses on either a credit or noncredit basis. Those who register on a noncredit basis merely pay a nominal fee of $2.00 to $5.00 and receive a copy of the course syllabus. They do not submit written work or take examinations.

The student who registers for credit pays the regular university tuition of $20 a credit hour and receives a copy of the syllabus, all of the homework assignments and the privilege of taking the final examination. Purchase of a textbook also is required of those enrolled for credit.

Detailed comparison of the academic records of the telestudents with campus students is available only for a course which was given some time ago. It is of interest to know that in Psychology 101, the Psychology Department used as a final examination, a test of 110 multiple choice answers which had previously been given to 1240 students on the campus. The median grade of the telecourse students was 13 points higher than those who took the course on campus. As a matter of fact, using the curve created by classroom student grades, 24% of the telecourse students would have received grades of "A" and not a single one would have failed the course.

The age range of those who reported during one typical year to have viewed the telecourses was from 19 to 68 years, with a median of 37 years. Their educational background varied from some who had not finished grade school to others who had completed their advance graduate work. Approximately 82% had completed high school and approximately 11% had completed college.

Varied Experiences

Similar success stories can be told from nearly fifty other institutions of higher learning. A recent report from the American Council on Education's Committee on Television reveals a total enrollment of 12,000 students in 170 regular academic courses of the air, as they were offered for credit by 44 different institutions. The report further disclosed that in addition to accredited students, there were estimated audiences of 75 to 100 thousand for some of the courses, bringing the grand total to a probable astronomical ten million.

Moving down the academic scale, there are equally interesting and exciting stories to be found at the secondary school level. An unusual experiment was attempted this past summer over Station WQED, the educational station in Pittsburgh. When the Pittsburgh Public Schools were obliged to discontinue their regular summer sessions because of lack of funds, the gap was filled via television. Nearly 500 high school students thus were able to make up their school credit deficiencies in English grammar and composition, American literature, algebra and United States history by paying a registration fee of $5.00 and by passing tests evaluated by the school district in which they were regularly enrolled. The total cost to the station was $13,000, in contrast to the $200 to $300 per student costs previously expended from school budgets.

Equally successful, if not quite so unusual, are the efforts of scores of school systems throughout the country that are planning and presenting television programs regularly throughout the school year in cooperation with local commercial or educational stations—programs designed to supplement the active day-to-day curriculum needs. The public and parochial schools of Philadelphia are perhaps the oldest in terms of experience, but equally successful are more recent efforts in Boston, Schenectady, New York City, Baltimore, Washington, Atlanta, St. Louis, Detroit, Cleveland, Columbus, Des Moines, Seattle and San Diego.

Moving off campus and out of the classroom, and using the broad definition of the term "educational" to encompass the good play, the concert, the symposium on current events, the scientific exposition and the newscast, the alert teacher finds rich resources for assigned out-of-school viewing on such series as Omnibus, Conversations (those delightful visits with some of the wise elders like Carl Sandburg, Robert Frost, Frank Lloyd Wright, Bertrand Russell and others), American Inventory, Adventure, the Johns Hopkins Science Review, Meet the Press, You Are There, Robert Montgomery Presents and Studio One, to name but a few; and such memorable treasures as the one-time showings of *Macbeth*, *Richard III*, *Peter Pan*, and the recent productions of *Skin of Our Teeth*, and *Our Town*, not to mention *Amahl and the Night Visitors*, the musical drama written by Menotti especially for television.

The Future

By assigning programs such as these and discussing them later in the classroom, the teacher is able to assist her students to become more discriminating in their viewing habits. Just as she has long recognized her responsibility for guiding and developing the reading tastes of her pupils, so now she must undertake the responsibility for developing good taste in listening and in viewing. Realistically she recognizes that what the child is and what he is to become, are influenced in no small degree by the television program which he views on an average of 2 to 3 hours a day.

Does not all this suggest that a vast adventure in education lies before the American people? And does not it also suggest that it calls for the collective

efforts of all of us? You, the engineers and technicians, in this great movement have a long and enviable record of achievement. It's a far cry from the days of the flickering motion picture to the reality today of color and wide screens; from the days when a speaker shouted at the top of his lungs in an auditorium, to the development of the sound system which makes it possible to bring thousands of listeners within easy range. And now you've put wings on our pictures in motion, so that they can be transmitted thousands of miles to waiting audiences!

Mechanical technology and electronics have expanded quite beyond the concept of the modern educator and we need your patience and your help to see to it that we harness these mechanical devices in such a way as to come safely to grips with this richest opportunity in history.

The need is defined, the means are at hand, and the prospects are limitless.

The Joint Committee on Educational Television—Its Aims and Purpose

By
E. ARTHUR HUNGERFORD, Jr.

The opportunity for organizing a concerted effort in the behalf of educational television arose from the so-called "freeze" in the construction of television stations which began in September 1948. TV broadcasting, whose early beginnings are traced back to the opening of the New York World's Fair in 1939, began to show a lusty growth pattern immediately after the war. It soon became apparent that the channels allocated for television usage were not sufficient to provide for a truly competitive national television service. It also became apparent that early technical criteria as to the propagation of television signals were based on inadequate information. To correct these important difficulties, the Federal Communications Commission decreed a freeze in new construction in 1948 and began a study of a new allocation plan.

The educational representatives, taking advantage of this "breathing spell," began to organize to present the case for educational television to the Federal Communications Commission.

Formation of the Joint Committee

On October 16, 1950, Richard Hull, then President of the National Association of Educational Broadcasters, called a meeting of representatives from seven national educational organizations who were already on record with the FCC as favoring reservations of television channels specifically for educational purposes. This meeting resulted in the organizing of an *ad hoc* committee known as the Joint Committee on Educational Television. Keith Tyler of Ohio State University was named Chairman, and Belmont Farley of the National Education Association was named Treasurer.

On November 27, 1950, hearings before the FCC began. With Telford Taylor as Counsel, the Joint Committee on Educational Television presented the case for educational reservations in behalf of the seven national educational groups.

Some 76 witnesses testified as to whether channels should be reserved for the exclusive use of educational institutions. Five of these witnesses opposed the reservations on the grounds that, for financial and other reasons, educators would probably not be able to use the channels, and that commercial broadcasters could provide sufficient time to meet educational needs. The remaining 71 supported the reservations, presented evidence of the need for educational television stations, and demonstrated the uses of television in both in-school and out-of-school education. They showed that educational organizations need more time than commercial interests to make plans and establish stations. A total of 838 colleges, universities, state boards of education, school systems and public service agencies submitted written statements urging the Commission to make the reservations.

Organized education gave magnificent support to the reservations. The constituent members of JCET, the American Council on Education, the Association for Education by Radio-Television, the Association of Land Grant Colleges and Universities, the National Association of Educational Broadcasters, the National Association of State Universities, the National Council of Chief State School Officers, the National Education Association of the United States—these, and many other national educational groups representing literally thousands of educational institutions, school systems, school administrators, teachers and other educators, joined in the crusade.

On March 22, 1951, under the aegis of the American Council on Education, the *ad hoc* Joint Committee on Educational Television was converted into a permanent Joint Committee on Educational Television. Richard Hull was appointed Acting Director and served as such for a short time before returning to his primary assignment at Iowa State University as Director of the University-owned television station WOI-TV, in Ames, Iowa. Ralph Steetle was then appointed Executive Director on May 14, 1951, and continues to this date, with headquarters at 1785 Massachusetts Ave., Washington 6, D.C.

Activities of the Committee

The JCET is active in the following areas:

(1) The Committee continues to protect the reserved educational channels and assist educators seeking to utilize these channels.

(2) The Committee advises applicants for television stations with regard to the legal, engineering and programming procedures necessary to conform to the regulations of the FCC. It also provides expert consultants to educational groups to assist them in achieving their educational goals.

(3) The Committee helps schools and colleges evaluate the resources available to them for possible television programming and encourages the interchange of cultural values as between regions of the country.

(4) The Committee assists in organizing state, regional and national conferences on educational television and provides the consultants to help such groups in their planning to use educational television wisely.

(5) The Committee distributes regular publications on the national status of educational television and acts to be certain that all areas can make use of the experience available from pioneer stations.

Since the first announcement of the tentative allocation plan for television broadcasting in this country, the JCET has continued to support the reservations for educational channels and to contest any attempts by commercial groups, or otherwise, to upset the concept of these reserved channels. There have been a number of attempts by interested parties to have the educational reservation removed in certain specific cities. This has been particularly true where scarce VHF

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channels are involved. The JCET has assisted the local authorities in combating these petitions. In all cases thus far they have been successful.

In addition to the extensive legal services which the JCET has performed are other services and functions of great importance to the progress of educational television. One of the most important of these functions is the participation by the JCET in special conferences called to bring together educational leaders to coordinate their efforts in this field. The first such important conference was known as the Educational Television Programs Institute and was held during April 1952 at Penn State College, State College, Pennsylvania (now Penn State University). With President Milton Eisenhower as host, a considerable number of college presidents and public education officials met to determine the best methods of using educational television. The results of this conference were far reaching for, occurring as it did only one week after the FCC announced the final television allocation plan, educators were clearly faced with the prospect of acting quickly to make use of the educational television reservations. If they did not do so, there was a good chance that commercial interests would be successful in acquiring some of the reserved channels.

Following the Penn State meeting there were many important state and regional conferences called to consider the activation of educational television channels. One of the most important of these was the California Conference, called by the then Governor Warren, and attended by 2,000 California educators. Committees examined every phase of the problem and the report which ensued represents a milestone in the coordinated action by a large group on an important state issue.

In December of 1952 the Southern Regional Educational Conference was held in Atlanta, bringing together representatives of the 14 southern states to consider plans for the use of educational television in the south. A similar conference was held in New England involving Maine, New Hampshire and Vermont.

The Joint Committee also participates in several major educational conventions providing demonstration of educational television, and setting up clinics to discuss the many problems which face operators and planners in this field. Included are the conventions of the American Association of School Administrators, the National Education Association, the National Association of Educational Broadcasters and the National Association of Radio and Television Broadcasters.

Consulting and Information Services

The JCET Consulting Services are one of its most valuable contributions. Permanently on the staff are C. M. Braum, Engineering Consultant, and Walter B. Emery, Legal and Program Consultant. In addition, there are many part-time consultants in a wide variety of specialties who are called in as needed.

In the public information area, JCET syndicates several publications designed to keep the national educational establishment appraised of all important developments. These are:

1. *JCET Reports*, a reference service in educational television, including analysis of applications for reserved channels; FCC action concerning the educational reservations; operation of stations; engineering developments and programming.

2. *Box Score* on educational television, a monthly report of specific progress in terms of applications filed, construction permits granted, and commencement of operation of stations.

3. *Round-Up of the Nation's Press*, a monthly report of general progress in educational television consisting of reprints of clippings from newspapers around the country.

(4) *Fact Sheet* for educational journals, a monthly publication emphasizing trends, statistics, total national development and including bibliography supplement, report of workshops scheduled and new station personnel appointments.

In educational circles it is well known that JCET is the most reliable and complete source of all information on educational television.

JCET today continues its dynamic program of service to a growing constituency. There are now 21 educational stations on the air. Three of these (Ames, Iowa, Notre Dame, Ind. and Columbia, Mo.) operate as commercial stations with added emphasis on educational programs, and 18 operate as nonprofit educational stations, all but one on reserved channels. These 21 cities are:

Houston, Texas (VHF)
East Lansing, Mich. (UHF)
Pittsburgh, Pa. (VHF)
Madison, Wis. (UHF)
San Francisco (VHF)
Cincinnati (UHF)
St. Louis (VHF)
Ames, Iowa (VHF)
Columbia, Mo. (VHF)
Detroit (UHF)
Seattle (VHF)
Chapel Hill, N. C. (VHF)
Munford, Ala. (VHF)
Birmingham, Ala. (VHF)
Lincoln, Neb. (VHF)
Boston (VHF)
Champaign, Ill. (VHF)
Miami (VHF)
Chicago (VHF)
Columbus, Ohio (UHF)
South Bend, Ind. (UHF)

Three other cities have stations under construction: Oklahoma City (VHF), Memphis (VHF) and New Orleans (VHF).

In many communities, organizations are actively working toward the operation of educational stations. Educational authorities have estimated that as many as 40 stations are in sight in the next two or three years.

The Record

When considered in proper context, this record by the educators is truly remarkable. It has taken great courage and vast organizational skill to combine the many interests into effective organizations to operate educational television stations. No community has been allocated more than one channel for educational purposes. This means that many organizations must work together if the channel is to be used wisely. The JCET has made its greatest contribution acting as a catalyst to bring about successful educational stations.

Definition and Evolution

There is great confusion as to just what constitutes educational television. With experience accumulating, the pattern is becoming clearer. It has been stated best perhaps by Dr. David D. Henry, President of the University of Illinois: "Educational television and radio is a misnomer. We should instead speak of televised education, so that the purpose, methods and outcomes will be measured by educational standards, not by entertainment and recreational standards, no matter how laudable or worth while the latter may be."

The greatest successes thus far have been in the areas where the program material has in effect been televised education. In-school programs both as supplementary and as direct curriculum support are becoming common practice in such cities as Seattle, St. Louis and Cincinnati. College level courses for credit and noncredit have also achieved substantial audiences. In the adult education field, many programs have succeeded in a great variety of subjects. It is becoming clear, therefore, that where educational television provides a new service in an area which it well understands, it finds a loyal audience.

So it seems that education is moving on a very broad front to make the maximum use of television as one tool in the learning process. The JCET can well take pride in the part it has played and will continue to play in assisting new educational groups to enter educational broadcasting and in counseling those stations presently on the air in the ever-present problems of day-to-day TV broadcasting.

A National Educational Television Program Service

By ALLAN M. DELAND

THE EDUCATIONAL Television and Radio Center is what the name implies, a Center for educational television stations—a Center in the sense of a national program exchange and also in the sense of a national program supplier.

When noncommercial educational television was still just an idea, far-sighted educators realized that some stations would have access to excellent resource-personnel and talent while other stations would suffer from the lack of these resources or the financing to develop them. Thus the idea of recording and exchanging the best programs from each station was an obvious development.

The Educational Television and Radio Center was established as a nonprofit organization with an initial grant from the Fund for Adult Education. Early in 1954 it started distributing educational programs to the few stations then on the air.

This paper is primarily a coverage of the technical operations of the Center so other aspects are noted only briefly.

The Center supplies a balanced program service in continuing series. As each series ends, it is replaced with another in the same general subject area. These program series are acquired by the Center in three basic ways:

(1) Exchange, which utilizes existing programs supplied by individual educational stations.

(2) Audio-visual films.

(3) Production under contract.

Exchange programs are for the most part television recordings made by educational television stations.

Audio-visual films, which are of varying length, are usually supported by a narrator who serves the dual purpose of explaining and expanding the film subject and filling the program to a prescribed time block.

Productions under direct contract are both television recordings and film productions.

The Center as a national exchange agency and a supplier of programs had first to consider the technical needs of the user of its programs and secondly to consider the available media of program communication. Upon reviewing the industry, one initial fact became immediately evident and this was that standard 16mm television recordings were the most economical type of production. Upon these premises, the center proceeded to establish standards. These standards were established after:

(1) determining the changes and distortion caused by transfer characteristics of the television film chain, the television transmitter and the average home receiver; and

(2) considering the quality achieved by producers of this type of television recording.

Upon reviewing the multitude of methods and procedures followed in producing television recordings and films, it was determined that no technical restrictions should be imposed on the producer if his final result was what the Center wanted; therefore, standards were limited to the description of a print.

The video portion was described in general terms of resolution, gray scale, etc., because there existed no practical technique for numerical evaluation.

The print density span was, however, described in photographic terms and was determined after considering:

(1) the operating limits of the image-orthicon pickup camera;

(2) the available light in most projectors; and

(3) the nonlinear characteristics of the negative film used.

A desirable print was described as one in which the significant densities range from 0.4 to 1.9, that is, in large areas or areas which contain important picture information. Unimportant small areas may exceed this range.

The audio was described in conventional terms of frequency response, distortion, signal-to-noise ratio and reverberation content.

As a means of communicating these standards and the many programs and legal requirements, the Center has compiled a *Production Handbook* which is available to qualified producers.

For viewing, a 40- by 60-in. screen is used at an average viewing distance of 14 ft. This gives a viewing distance of about 4½ picture heights which appears to be an optimum analytical viewing condition, because at this point errors in the projector optical system are only slightly apparent and the viewer does not confuse them with shortcomings on the film. If a smaller viewing aspect is used, some of the fine points, such as the focus differences between cameras, are easily overlooked. Films are not viewed to obtain the effect on television but to analyze their technical qualities. The sound is reproduced with a 15-in. speaker in a 5-cu. ft. base-reflex cabinet, which, combined with a modified projector sound system, reproduces about everything on the film so that an accurate sound evaluation may be made.

Kine-Recording Experience

As might be expected, the Center has encountered its greatest difficulties with television recordings. To assist this problem a consulting service has been set up so the educational units producing for the Center may have excellent technical assistance at no cost to them. This service takes two forms; a consulting engineer visits the production unit and assists with his experience and know-how, then an evaluation and report back are given on examples of recordings submitted monthly.

Of the various errors evident in many television recordings previewed by the Center, three predominate, in this order:

(1) Lack of resolution.

(2) Poor gray scale.

(3) Poor sound pickup.

These indicate a fact that the consulting engineers have verified consistently. Many complaints against television recordings should be directed at the studio technical crew and sometimes as far back as the lighting or the set.

The Center maintains only viewing and editing facilities. It has two screening rooms and editing equipment to the extent of a moviola, a viewer, an optical sound reader, a magnetic reader and the necessary accessories plus the evaluation tools of a microscope and a densitometer.

All prints are previewed, labeled, inspected and, when necessary, edited by the Center before turning them over to our distributor, which is the University of Illinois. This distributor inspects and, when necessary, repairs prints after each station usage. In the event of damaged film, the spot is viewed and listened to and, if an appropriate cut is practical with no change in meaning or sense, a splice is made and blooped. Otherwise, replacement footage must be ordered and inserted. Stations are requested not to repair films more than is necessary to air them.

Temperature, apparently, has only a minor effect on films in storage. Humidity, however, must be controlled. A dehumidifier is in constant use throughout the summer and water-boiling is occasionally necessary in the winter. By following these procedures, the Center is able to maintain a high standard of technical quality and obtain maximum usage from each print.

Most programs are one-half hour long and there are an average of five prints per program. The Center supplies a mini-

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mum of 5 hours a week to 16 stations; this adds up to more than 150 cans of film shipped each week. All distribution planning is done at the Center but the shipping, inspecting and maintaining are done by the Visual Aids Service of the University of Illinois. Upon the Center's specifications, they set up a special Television Film Dept. which required certain departures from the usual audio-visual practices and incorporated most standard motion-picture film handling practices.

The Educational Television and Radio Center by first establishing practical standards, then adhering to them, has been able to serve adequately the ever-increasing number of educational television stations, although at present the best TV recordings made commercially or educationally are only slightly more than adequate.

The Center looks forward to higher standards and improved techniques for television recording and perhaps an improved medium.

DISCUSSION

Louie L. Lewis (*Radio Corp. of America*): The Fund for Adult Education has naturally been putting considerable emphasis on adult education. Has any emphasis been put directly on grade school or in-school type of work?

Mr. Hungerford: The Fund for Adult Education is, as its name implies, interested in that phase of education; however, the Fund for the Advancement of Education has been very active in the subsidiary areas of secondary and elementary education. There is a high school series going on in Pittsburgh, following up on a summer session which will continue all during this next term. This is backed by the Fund for the Advancement of Education, which is also backing the New York University experiment.

Glenn E. Matthews (*Eastman Kodak Co.*): The Papers Committee, in planning this morning's session, recognized the development in this subject as a significant trend in this country in the field of education. Many people have probably read of the problems of getting teachers, and particularly good teachers, and of paying sufficient salaries to new persons who show an interest in the field of teaching. As engineers, but more important, as American citizens, we have a tremendous responsibility toward the future to do everything possible to bring out the proper balance on educational aspects of our particular country. It seems to me that this new tool of television is one way of offsetting the trend of teachers away from teaching. I feel we have a strong obligation to encourage this new tool and its uses. Specifically, I wanted to ask if any attempts have been made to beam in the programs of educational television to the state fairs of the country.

Mrs. Broderick: The state fairs are one real possibility that, to my knowledge, has not been tapped. At the various educational conventions throughout the country we have put on demonstrations to illustrate the kinds of programming that are being done by the Program Center, at Ann Arbor, as well as by schools and community organizations. We also have demonstrated the classroom utilization of a certain television program by having a teacher with a group of children show what she would do with a program as she and the children viewed it and discussed it in a simulated classroom experience. Mr. Matthews has given us an excellent suggestion for spreading the gospel still further, particularly beyond the professional groups which we have been reaching so far.

Cecil S. Bidlack (*National Assn. Educational Broadcasters*): I would like to add a comment to Mr. Lewis' question. While the Fund for Adult Education is not participating directly in a program of in-school broadcasts, there are a number of educational stations that are connected with school systems such as at St. Louis, Pittsburgh and Seattle, where they're actually doing in-school broadcasts.

Mr. Hungerford: In looking at the growth of the American economy through the years, there is perhaps only one significant thing to be said: that is, that the productivity of the individual worker has been increased. If this is applied to education, the rule there is that somehow we must extend the usefulness of the individual teacher via every mechanical tool at our disposal in order to get greater efficiency in the educational system.

Reid H. Ray (*Reid H. Ray Film Industries*): What percentage of the students who sign up for TV courses actually complete them?

Mrs. Broderick: Between 35 and 40 per cent of those who register and pay fees continue through to the end. A considerably lesser percentage see the courses through if they have not paid the registration fee.

Thomas T. Goldsmith, Jr. (*Allen B. Du Mont Laboratories*): Yesterday we gave a paper on the Electronicam system of film recording using television techniques. We have done a series of 16mm recordings at Columbia University on educational television subject matter which turned out very well. And the quality of film record there on 16mm, done for economy's sake, is far superior to what you get on a regular kine recording. We discussed this with Dr. Partridge who worked with the Montclair State Teachers College educational television work. We hope to do this kind of work in the educational field in other places too.

Mr. Bidlack: I would add to Mr. DeLand's paper that the Fund for Adult Education has made grants of funds to most of the educational stations now on the air; the grants were used to purchase kinescope recorders. In that way they are promoting the production of programs for the center. I'm sure most educational stations would like to put their programs directly on film, if that were possible, and no doubt they would like to use this Electronicam system; however, lack of money seems to be their big difficulty.

D. Lisle Conway (*General Electric Co.*): Has the JCET approached any of the major electronic manufacturers regarding the specific design of either pickup or kine equipment to be used for your particular purpose, and if so have you been able to tell them how much of this equipment you would require?

Mr. Hungerford: No, there were no specific approaches along that line. We have standard broadcast equipment in the studio work throughout the country and kinescope recordings were mainly of two types—largely General Precision Laboratory with several RCA recordings.

Mr. Conway: The reason I asked is that several of the manufacturers are building up an inventory of equipment which is either obsolete or taken in trade and some of this equipment might be used for your purpose if you were to approach the manufacturers and make your needs known.

Mr. Hungerford: It would be well to follow your suggestion.

Lt. S. P. Dittman (*Army Medical Center, Washington, D.C.*): Another area in which color TV has great promise is its use in medical education and research. An example of success in this area is the University of Utah's open circuit programs to remotely located practicing physicians. Their Audience reaction surveys indicated that these programs were most informative and well received. Also, in the past four years or so, a few of our medical schools, the AMA, and the Smith, Kline and French laboratories have used, and still are using effectively, the closed-circuit color television systems.

At the Walter Reed Army Medical Center in the last two years, our color closed-circuit system has aided materially in the teaching of surgery and other medical subjects which otherwise have restricted viewing areas.

Editorial Note: The Army Medical Center's work of the past two years was summarized in a large, three-paneled color transparency exhibit outside the session meeting room. Also, the field of televised education was covered by a poster exhibit provided by the National Citizens Committee for Educational Television.

The Role of Resolving Power and Acutance in Photographic Definition

By GEORGE C. HIGGINS
and ROBERT N. WOLFE

The method of measuring resolving power and the factors that influence the measured value are first described. The concept of acutance, which is an objective quantity that correlates with sharpness, is then explained. Experiments have shown that no unique correlation exists between definition, which is the quality aspect of a photograph that is associated with the clarity of detail, and either resolving power or acutance. A good correlation was found between acutance and definition, provided the resolving power was greater than about twice that of the eye for the conditions under which the photographs were viewed. A correlation with acutance was also found for lower values of resolving power when the acutance was weighted with a suitable function whose parameters depend on the resolving power and the conditions of viewing.

The term "photographic definition" as used in this paper refers to the quality aspect of a photograph that is associated with the clarity of detail. This is the sense in which the term has been used explicitly by the authors elsewhere[1] and in which it is used implicitly by other writers. The concept of definition is subjective because definition is an impression made on the mind of an observer when he views a photograph. Definition in this sense is a composite effect of at least four subjective factors: resolving power, sharpness, graininess and tone reproduction. In this paper, the relation of two of these factors—resolving power and sharpness—to definition will be discussed.

Communication No. 1749 from the Kodak Research Laboratories, presented on April 21, 1955, at the Society's Convention at Chicago, by G. C. Higgins (who read the paper) and R. N. Wolfe, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received September 5, 1955.)

Resolving Power

The ability of a photographic material to record fine detail distinguishably is known as resolving power. The obvious way to measure this quantity is to photograph a suitable pattern on a greatly reduced scale and then to examine the resulting developed image at whatever magnification is required to see the smallest detail that is resolved. Several of the patterns that have been used by various workers are shown in Fig. 1. In the Kodak Research Laboratories, extensive measurements of resolving power have been made on a series of films with some of these patterns.[2] While the absolute values depended upon the type of pattern, the relative ordering of the films was essentially independent of the type. The test

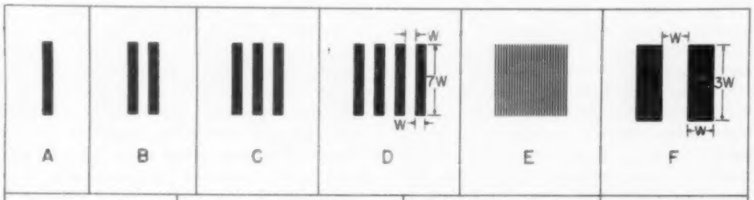

Fig. 1. Typical patterns for measuring resolving power. In every case, the spaces have the same width *W* as the adjacent lines.

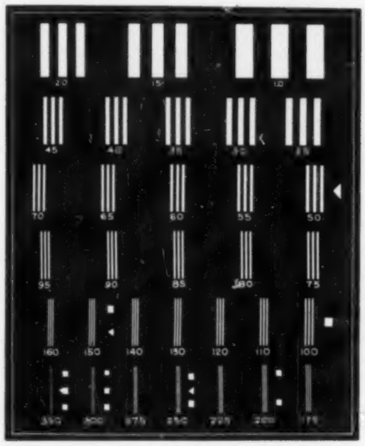

Fig. 2. Scheme of the test object used in the Kodak Research Laboratories. The numerals, which do not appear on the test object itself, represent the number of lines per millimeter in the image of each group on the sample.

object regularly used in these Laboratories, which is shown in Fig. 2, consists of a series of three-line (tricolumnar) patterns in which the lines and spaces are of equal width and the length of the lines is great compared with their width. The number below each group of lines is the reciprocal of the distance in millimeters between the centers of adjacent lines when the test object is copied at a reduction of 75 times, this being the reduction in the particular camera used. For this reduction, the numbers therefore represent the number of lines per millimeter.

Since resolving power varies greatly with exposure, it is customary to make a graded series of exposures to the test object. From this exposure series, resolving power is plotted as a function of exposure in the manner shown by Fig. 3. The broken curve is the D-log E characteristic curve of the photographic material. By plotting resolving power as a function of exposure on the same log-E axis, it is possible to relate resolving power to density. Each of the three resolving-power curves refers to a different luminance ratio in the test object, as indicated by the values of ρ. For all materials and all exposures, resolving power increases with the luminance ratio or contrast in the test object as exemplified by this figure. The single value of resolving power which is normally given for a material is the maximum value, irrespective of the density at which this maximum occurs, and for

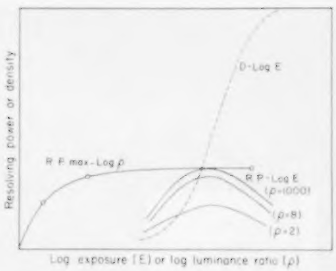

Fig. 3. Typical graph showing (a) *D*-log *E* curve as measured on an area of uniform density, (b) resolving power vs. log exposure for three values of luminance ratio in the test object and (c) maximum resolving power, regardless of exposure, vs. log luminance ratio.

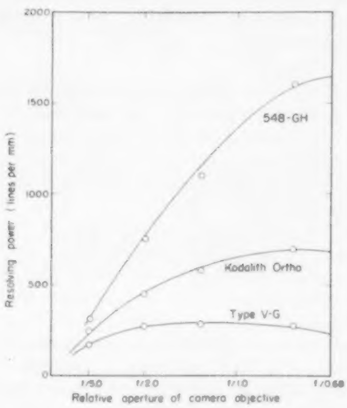

Fig. 4. Resolving power of three materials vs. *f*-number of the camera lens in light of $\lambda = 546\ m\mu$.

different materials, this maximum can occur at quite different densities. When the maxima for the various contrasts are plotted as a function of log luminance ratio, the approximately exponential curve in the figure is obtained. This curve always has the same general shape although it varies in detail with the material.[2] When the material must be characterized by a single value, the value for a luminance ratio of infinity is usually given. It is evident that this or any other single value is only a part of the resolving-power story. For example, the resolving power might be very high at unit density and yet it might drop very rapidly as the density decreased to 0.5 or increased to 1.5. The important feature is not the maximum resolving power, but whether the resolving power is ample over the range of densities that is to be used in making the negative.

Experience indicates that it is incorrect to speak of the resolving power of a film or the resolving power of a lens by itself. More correctly, one must speak of the resolving power of the lens–film combination. This is illustrated in Fig. 4, in which the resolving power is plotted as a function of the relative aperture of the camera objective used to make resolving-power images on a series of different photographic materials.[3] The open points for an aperture of *f*/5 represent the data obtained with an unusually well corrected lens used for routine determinations on ordinary photographic materials. While there is a real difference in resolving power between the various materials as measured with this lens, all the values are relatively low, being of the order of 300 lines/mm for the best material. However, when these same materials are exposed in the same manner with a lens having an aperture of *f*/0.8 (the open points at the extreme right), the resolving power of the 548-GH sample, which is a high-resolution film,* is increased from 300 to 1600 lines/mm. What is the resolving power of this film? Clearly, it depends upon the lens that is used to photograph the test object.

The lens used in the resolving-power camera in the Kodak Research Laboratories from 1917 to 1944 was a well-corrected telescope objective. In the latter year, it was supplanted by the *f*/5 lens mentioned above, which is an air-spaced triplet with especially good correction for axial objects.[4] When the resolving powers of the materials manufactured by Eastman Kodak Co. were remeasured with the new lens, there was a general increase in the values compared with those obtained by the use of the telescope objective. For example, the resolving power of Kodak Super-XX Film (amateur roll) increased from 50 lines/mm with the old lens to 95 lines/mm with the new one.† This raises the question of what is the resolving power of this material. It is clear that resolving power is not a unique function of the material, but is a function of the lens–film combination.

The quality of the image formed by an optical instrument was first evaluated quantitatively by the astronomers, and since much of their work formerly involved the optical separation of objects having small angular dimensions, such as stars, they evaluated quality in terms of what we now call resolving power. It was therefore natural that, when the detail-rendering ability of the photographic plate was first studied around the turn of this century,[5] it should also be evaluated in terms of resolving power.[6] No better quantitative criterion having been known, the resolving power of photographic materials and methods of improving it have been studied assiduously, and a great deal has been learned.[7] This preoccupation with resolving power was justified because, in general, emulsions of high resolving power make better pictures than emulsions of low resolving power. However, evidence has accumulated to indicate that resolving power does not always correlate with definition and in some instances may even be misleading. An example of this was given in an earlier paper in this *Journal*.[8]

* Eastman Spectroscopic Film, Type 548-GH.

† This new lens is used for materials of 120 lines per mm resolving power or lower, since a lens of higher aperture does not cause the value of these materials to increase. Materials of higher resolving power are tested with suitable lenses of higher aperture.

Sharpness and Acutance

Resolving power evaluated as just described is an important property of a photographic system. Nevertheless, it is a measure of only one of the factors affecting definition, namely, the ability of the system to reproduce, distinguishably, detail that is closely spaced. When a system has adequate resolving power to reproduce all the detail that can be distinguished by the human eye for a given condition of observation, the quality of definition in the photographic reproduction is still dependent upon the sharpness of the image, that is, upon the appearance of the edges of well-resolved detail. For example, when a photographic film *F* in Fig. 5 is exposed while partially shielded by a knife-edge *K*, the image after development does not end abruptly at the knife-edge. Instead, as shown by the microdensitometer trace in the figure, which represents the variation of density with distance across the edge on an enlarged scale, the image exhibits some drop in density near the boundary on the side which has received the high exposure and an increase in density in the region which has been shielded from exposure and which should be clear. This shading of the developed image from the illuminated side of the edge to the unilluminated one can result from such causes as development and adjacency effects or the turbidity of the emulsion so that light is diffused laterally in the emulsion.

It has appeared for some time that an edge trace, such as is shown in this figure, should give all the information required to obtain an objective evalua-

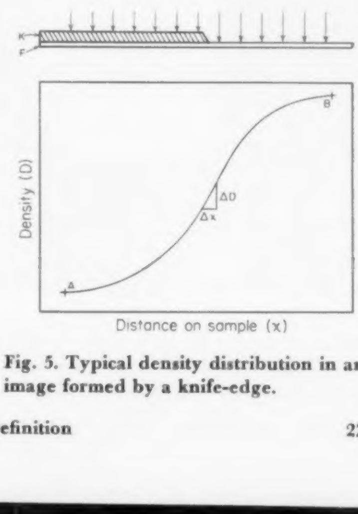

Fig. 5. Typical density distribution in an image formed by a knife-edge.

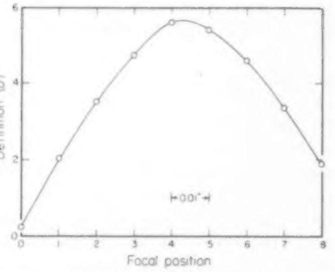

Fig. 6. Definition in statistical (σ) units vs. the distance of the film from the lens, the object being stationary.

tion of the sharpness of the image, and indeed the late L. A. Jones and G. C. Higgins devised an objective measure of sharpness on this basis that was described in a paper[8] before this Society in 1952.

The procedure for obtaining this measure consists in dividing the edge trace into elementary sections having a constant length Δx and determining the slope of $\Delta D/\Delta x$, as shown in the figure, for each elementary section of the entire curve between certain limits, A and B. The average of the square of these gradients, $\overline{G_x^2}$, is then computed by the equation

$$\overline{G_x^2} = (1/N)\Sigma(\Delta D/\Delta x)^2, \qquad (1)$$

where N represents the number of intervals of length Δx between A and B. Since it seemed likely that the subjective impression of sharpness should depend not only on this quantity but also on the total density scale

$$DS = D_B - D_A, \qquad (2)$$

which is the difference in density between the two edges of the trace, it was originally suggested that the product $\overline{G_x^2}\cdot DS$ might be the quantity that correlates with sharpness for varying values of DS. This objective correlate of sharpness was termed *acutance*. It was pointed out in the original paper that all the acutance values therein were obtained across edge traces having the same density scale and that the way the factor DS enters, if it enters at all, was therefore hypothetical at the time. On the contrary, the present experimental data point to the likelihood that acutance should be defined as the *quotient* of $\overline{G_x^2}$ and DS.

This definition of acutance can be seen to have some intuitive significance. It can be proved mathematically that

$$\overline{G_x^2}/DS = \overline{G_D}/(x_B - x_A), \qquad (3)$$

where $\overline{G_D}$ is the average gradient $\Delta D/\Delta x$ measured at equal increments of D rather than equal increments of x, and $(x_B - x_A)$ is the distance over which the gradient exceeds a certain limiting value. Now $\overline{G_D}$ is the stimulus, and the greater the stimulus, the greater is the sensation of sharpness. On the other hand, $(x_B - x_A)$ represents the distance over which the stimulus evokes a sensation, and it appears reasonable to assume that the shorter the distance across the edge over which the stimulus evokes a sensation, the greater is the sensation of sharpness. This effect of the term DS is being actively investigated. For the present, whenever possible, all values of acutance will be determined by comparing edges for which the term DS is a constant.

Definition

In the earlier paper,[8] it was shown that when the resolving power of a series of pictures is well above the limit set by the eye for the conditions of viewing, and when there is no apparent difference in graininess or tone reproduction between the pictures, acutance correlates well with judgments of definition. To investigate the effect of resolving power on definition when it is at the limit set by the eye or lower, a series of pictures[1] was made in which both resolving power and acutance varied while graininess and tone reproduction remained constant. Photographs were made with one lens, one film and one test object, the latter being an aerial photograph. The changes in resolving power and acutance were introduced by making the photographs at different focal positions, that is, with different distances between the lens and the film while the distance of the test object from the lens remained constant. The independent variable in these experiments was thus the position of the film in the camera along the lens axis, the position of the focal plane being bracketed. Matched prints were made from the resulting negatives, and these prints were ranked statistically for definition by a number of observers following a method recently outlined by Morrissey.[9] The relative definition of the various pictures in terms of the statistical parameter σ for a normalized function is plotted as a function of focal position in Fig. 6. It will be noted that the definition varied significantly as the film was moved from focal position 0 to 8, being a maximum for position 4 and only slightly lower for position 5.

Corresponding transparencies were made of the test object shown in Fig. 7, which consists of a large square for determining acutance and graded tricolumnar patterns for determining resolving power. The negatives for these transparencies were made at the same focal positions as for the aerial scene. The average values of resolving power and acutance were determined for each focal position from these transparencies. The relative definition of the prints is plotted as a function of mean resolving power $\overline{RP}$ and mean acutance $\overline{A'}$ in Fig. 8.

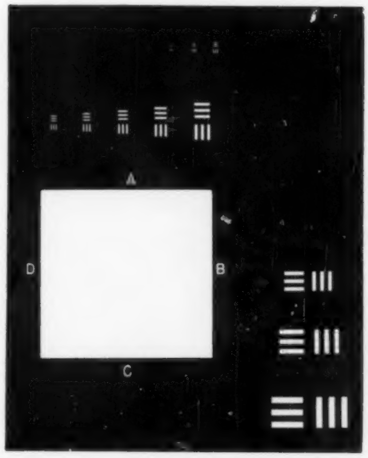

Fig. 7. Test object containing patterns for measuring resolving power and acutance.

Each focal position is represented in Fig. 8 by the same number as in Fig. 6. It is significant that these numbers rotate counter-clockwise in the curve for resolving power, as shown on the left, but clockwise in the curve for acutance, as shown on the right. This suggests that some mathematical combination of acutance and resolving power should furnish a quantity which will correlate with definition. The relation of average acutance to definition is approximately linear for focal positions 2 through 5. The curve for resolving power shows that for these focal positions, the average resolving power is greater than 20 lines per mm (logarithm = 1.3), which is approximately twice the maximum resolving power of the eye for the given conditions of observation, namely, when the pictures are viewed without magnification from a distance of about 14 in.

The fact that acutance correlates well with definition when resolving power is greater than 20 lines/mm suggests that, as mentioned previously, *acutance is the determining factor in definition when the resolving power in a photograph exceeds about twice that of the eye for the conditions of observation.* Thus, acutance might be multiplied by a factor which is a function of resolving power but which approaches unity and thus has no effect when the resolving power exceeds about twice

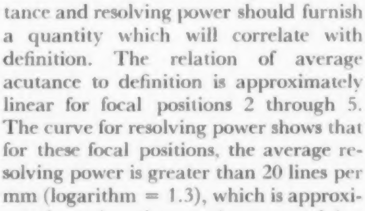

Fig. 8. Definition in statistical (σ) units vs. (a) the mean resolving power $\overline{RP}$ of the picture to which Fig. 6 refers and (b) the mean acutance $\overline{A'}$.

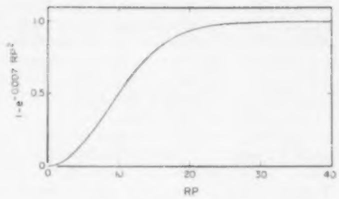

Fig. 9. Graph of the function that was used for modifying the values of acutance plotted in Fig. 8 to furnish an objective correlate of definition.

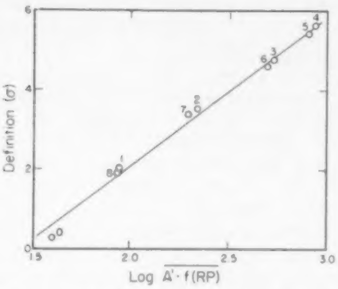

Fig. 10. Definition in statistical (σ) units vs. the function log $\overline{A'\cdot f(RP)}$ for each of the focal positions represented by the abscissas of Fig. 6. The straight line was drawn by the method of least squares.

the resolving power of the eye for the conditions of observation, although it becomes increasingly significant as the resolving power diminishes below this value. The exponential function $(1 - e^{-0.007RP^2})$ plotted in Fig. 9 satisfies these conditions. The constant 0.007 was selected in accordance with the resolving power of the eye for the conditions under which the pictures were judged for definition, namely, without viewing aids from a distance of 14 in., and would doubtless be different for other conditions. The mean value of the product of acutance and this function of resolving power is plotted as a function of definition in Fig. 10. There is now an excellent correlation between the two quantities.

If the quantity $A'\cdot f(RP)$, when averaged over a photograph, correlates with the definition of the photograph as a whole, it should likewise represent the definition at individual points within a single photograph. Figure 11 shows the acutance A' and the resolving power RP as a function of field angle for focal position 2. The broken curve shows the quantity $A'\cdot f(RP)$. A close examination shows that resolving power is low in those parts of the field where the acutance is high, and *vice versa*. Nevertheless, this relation between resolving power and acutance should not be taken as indicative of a general rule; it appears only when the resolving power is limited by lens aberrations rather than by diffraction, or by a failure to focus the lens sharply, as in the present instance. When the resolving power is limited only by diffraction, as in the case of a sharply focused axial image made by a good lens at a moderate aperture, the conditions that lead to a high resolving power also lead to a high acutance.

Images of the resolving-power and acutance test objects as obtained at two different points in the field for focal position 2 are shown in Fig. 12. The image at the left was made on the axis of the lens. At this position in the field, the image of the square is quite sharp but even the coarsest lines in the resolving-power test object are hardly resolved. In the image at the right, made at a field angle of 15° off the axis, the finest lines in the resolving-power chart are resolved. However, the image of the square is now unsharp. This pair of pictures shows conclusively that, while both resolving power and acutance are important in overall definition, one can be high and the other low simultaneously. Moreover, when the portions of the aerial photographs at these points in the field were judged at the normal viewing distance of 14 in., they were considered to have equal definition, as would be expected from Fig. 11. The picture on the axis (lefthand image) had all edges and all isolated material very sharply delineated but the observers were unable to detect some fine structure, such as branches, telephone wires and other minute details. On the other hand, while the picture at 15° from the axis (righthand image) reproduced the fine detail satisfactorily, the well-resolved details, such as the edges of buildings, were quite unsharp.

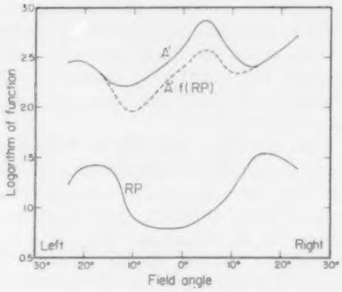

Fig. 11. Resolving power, acutance and the combined function described in the text vs. field angle for focal position 2.

Discussion and Conclusions

It must be emphasized that the examples cited represent such a limited amount of data that they should not be used as a basis for general conclusions. The data were obtained from photographs made with only one negative and one positive emulsion, and the characteristics of the photograph were varied in only one particular way, namely, by varying the focal position of the film. It should also be emphasized that in this investigation of the relation of acutance and resolving power to definition, the measurements of acutance and resolving power were made on the positive transparencies. The relation of acutance and resolving power in the print to the corresponding properties of the lens, the negative and the printing system are now being investigated. The negative material has hitherto received most of the attention, but the other factors cannot be disregarded.

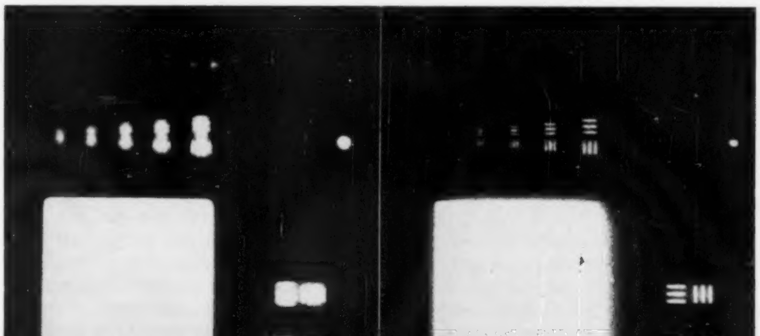

Fig. 12. Reproductions (enlarged) of the images of the test object at focal position 2 for two points in the field where the definition was found to be equal. Left, on the axis, where acutance is high but resolving power is low; and right, 15° to the right of the axis, where acutance is low but resolving power is high.

If a certain printing process will not make a print having a resolving power greater than 10 lines/mm when the negative has a resolving power of 100, of what avail is it to increase the latter figure to 200?

This objective measure of definition based on acutance and resolving power has been used to analyze a set of color motion pictures which had significant differences in definition. The objective evaluations ranked all the pictures in exactly the same order as the judgments of definition by 22 observers. Consequently, we feel that the objective quantity represented by the combination of acutance and resolving power correlates so closely with definition that it can be used tentatively as a basis for evaluating this aspect of picture quality, even though further study may indicate that it may have to be modified to some extent to fit various situations.

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The Effect on Definition of the Stage at Which Reduction Is Performed in Reduction-Printing Processes

By G. C. HIGGINS,
R. L. LAMBERTS
and R. A. PURDY

When reduction prints are made by a process involving duplicating positives and negatives, the size reduction can be made at any convenient stage. Color prints have been prepared from color negatives at a reduction of two to one and ranked for definition. The reduction was made at a different stage for each print, and it was found that, for best definition, the reduction should be postponed to as late a stage in the process as is feasible.

With the advent of various types of wide-screen motion pictures, the increased magnification required to fill the larger screens has resulted in an apparent decrease in definition on the screen. Since the positive materials have significantly lower graininess, higher resolution and better sharpness than negative materials, one way to improve definition is to increase the size of the negative and make the prints by a reduction-printing process. The question then arises as to the optimum size of negative from a practical standpoint.

The subject of definition and its relation to such characteristics as resolving power have been discussed in the preceding paper,[1] but for the present purpose, an empirical approach was called for rather than an analytical study. A series of negatives of the scene was therefore prepared in which the negatives had relative sizes of 1, 1.5, 2 and 3. The negatives were made by copying a masked 8 × 10 Kodak Ektachrome transparency on Eastman Color Negative Film, Type 5248. All the negatives were made with a 90mm $f/4$ lens, and the size of the images was varied by varying the object distance. The larger negatives were then reduction-printed on Eastman Color Print Film, Type 5382, with a standard Acme printer. The reductions were such that all prints were of the same size as the contact print from the smallest negative. These prints were then judged for both definition and graininess. Every judge considered the contact print to be inferior from the standpoint of definition to the prints made from the large negatives, but there was little indication of any preference among these latter prints. From the standpoint of definition, then, the optimum relative size of negative to positive is 1.5:1 in the case of these particular materials. When the same prints were judged for graininess, every observer chose the print made at a reduction of 2:1 over the print made at a reduction of 1.5:1. However, only 68% of the observers chose the print made at a reduction of 3:1 over the print made at a reduction of 2:1.

These prints were all direct optical reductions involving no intermediates. For this condition and for these particular materials, then, the optimum practical reduction for good definition and low graininess is 2:1. There would be only a small decrease in graininess and no improvement in definition if the relative size of the negative to the positive were made 3:1.

Passing now to the common situation where the printing process involves intermediate separation positives and internegatives and assuming that the overall reduction is 2:1, the question arises as to the best stage for making the reduction. To investigate this problem, two negatives were prepared which had relative sizes of 2:1, the larger of the two being a standard 35mm frame so that all the printing operations could be performed on standard equipment. These negatives were made by copying a masked 8 × 10 Ektachrome transparency on Eastman Color Negative Film. All the negatives were made with a motion-picture camera fitted with a 90mm, $f/4$ lens, and the image size was varied by varying the object distance. The negatives were made by copying a two-dimensional picture to eliminate the changes in definition that would be introduced by changes in depth of field if an actual three-dimensional scene were photographed. In this paper, the only parameters are the size of the negative relative to the positive and the stage in the process where the reduction is performed. The seven procedures to be described are indicated graphically in Fig. 8. The problems associated with changes in depth of field and perspective are discussed in the following paper.[2]

To obtain a print for comparison, the smaller negative was contact-printed directly onto Eastman Color Print Film, as shown schematically in the sixth line of Fig. 8. A single frame from the motion picture is shown in Fig. 7.

The larger negative was printed at a reduction of 2:1 directly onto Eastman Color Positive Film, as shown schematically in the third line of Fig. 8. A single frame from the motion picture is shown in Fig. 3. This reduction print has the same size as the contact print from the smaller negative. When this print was compared with the contact print, every observer agreed that it was much sharper and finer-grained.

The same negative was then printed at a reduction of 2:1 on Eastman Panchromatic Separation Film, Type 5216. These separation positives were then contact-printed onto Eastman Color Internegative Film, Type 5245, and this color internegative was contact-printed onto Eastman Color Print Film, Type 5382. This process is shown schematically in the last line of Fig. 8. A single frame from this print is shown in Fig. 6. Every observer judged this print to be inferior from the standpoint of both graininess and sharpness to the previous print (Fig. 3) representing a direct reduction from the same negative without intermediates.

The negative was next contact-printed onto the separation positives and the separation positives were printed at a reduction of 2:1 onto the color internegative, which was, in turn, contact-printed onto the color positive, as shown schematically in the fifth line of Fig. 8. A single frame from this print is shown in Fig. 5; 91% of the observers chose this print as having better sharpness and finer detail than the previous print (Fig. 6).

As shown schematically in the fourth line of Fig. 8, a print was then made by contact-printing the color negative onto the separation positives, contact-printing the separation positives onto the color internegative, and printing the color internegative at a reduction of 2:1 onto the color positive. A single frame from this print is shown in Fig. 4. Only 64% of the observers reported that this print had finer grain and better sharpness than the previous print (Fig. 5).

The negative was also contact-printed directly onto the color positive, as shown schematically in the first line of Fig. 8. A single frame from this print is shown in Fig. 1 enlarged to the same size

Communication No. 1763 from the Kodak Research Laboratories, presented on April 21, 1955, at the Society's Convention at Chicago, by G. C. Higgins (who read the paper), R. L. Lamberts and R. A. Purdy, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y. (This paper was received October 26, 1955.)

as the others. To make judgments of relative definition between this print and others in this series, it was projected with a lens having twice the focal length employed for projecting the reduction prints. Under this condition of projection, where all the pictures are of the same size, as in the color plate accompanying this paper, every observer stated that this contact print of the larger negative had the best definition and the lowest graininess of any picture in the series.

The final print was made as shown schematically in the second line of Fig. 8. The larger negative was contact-printed onto the separation positives, the separation positives were contact-printed onto the color internegative, and finally the color internegative was contact-printed onto the color positive. A single frame from this picture is shown in Fig. 2. This print was judged by all observers to be less sharp and more grainy than the print of the same size which was made by contact printing (Fig. 1).

It should be emphasized that, with the exception of the contact print from the small negative (Fig. 7), all prints in this series were made from the same identical negative.

When these negatives of the masked Ektachrome transparency were made, a resolving-power chart and an acutance test object consisting of an isolated square were also photographed. The values of resolving power, acutance and relative definition obtained with the use of these test objects are tabulated in the chart of Fig. 8. The values of resolving power in lines per millimeter as measured in the print are in the first column. The second column gives the values of acutance, $\overline{G_x^2}/DS$, which is the objective correlate of sharpness, as described in the preceding paper. The unit of distance used in evaluating G_x was the millimeter.* The third column gives the relative ordering of the pictures from the standpoint of definition as judged subjectively, the first having the best definition and the last, the poorest. The last column indicates the percentage of observers who placed the pairs of adjacent prints in the order shown.

An examination of the resolving power indicates that this criterion by itself is of little use in ranking materials from the standpoint of definition. The best print does have the highest resolving power; however, the next two prints, in order of definition, have essentially the same resolving power even though every observer stated that one has significantly better definition than the other. Similarly, the last four prints all have essentially the same resolving power while they differ significantly in definition, as indicated by the judgment column at the right. On the other hand, the acutance values, $\overline{G_x^2}/DS$, ranked the materials in exactly the same order as the subjective judgments of definition.

Since the relative values of definition shown here were obtained by comparing still pictures, it seemed desirable to verify these conclusions by motion pictures. A motion-picture print was therefore made from each of the various negatives, and it confirmed the judgments made on the still pictures.

* The ordinary unit for such minute distances is the micron, but the millimeter leads to a value of acutance 10^6 times as large and avoids the use of decimals within reasonable limits of precision.

Conclusions

On the basis of these data, therefore, it was found, as might be expected, that the farther one proceeds before making the final reduction in a reduction-printing process employing intermediates, the better the definition. It is especially desirable to make the separation positives the full size of the negative because the loss of definition (as compared with contact-printing) is much greater when the reduction takes place in making these positives than when it takes place in printing them on the internegative.

It is important to note that, while as far as possible all printing operations, both contact and optical, were made in accordance with good motion-picture practice, the results from a quantitative standpoint must depend upon the characteristics of the lenses and the printers. Moreover, these conclusions apply only to the specific films investigated. Although these conclusions might be different for other materials and may be modified by improved printing techniques or improved photographic materials, they are in qualitative agreement with present-day practice.

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Figures 1-8 follow on pp. 34 and 35

Fig. 1. Large negative; large print. Direct print by contact.

Fig. 2. Large negative; large print. Printed through intermediates; no size reduction.

Fig. 3. Large negative; small print. Direct print with reduction.

Fig. 4. Large negative; small print. Printed through intermediates; reduction in making release print.

Fig. 5. Large negative; small print. Printed through intermediates; reduction in making color internegative.

Fig. 6. Large negative; small print. Printed through intermediates; reduction in making separation positives.

Fig. 7. Small negative; small print. Direct print by contact.

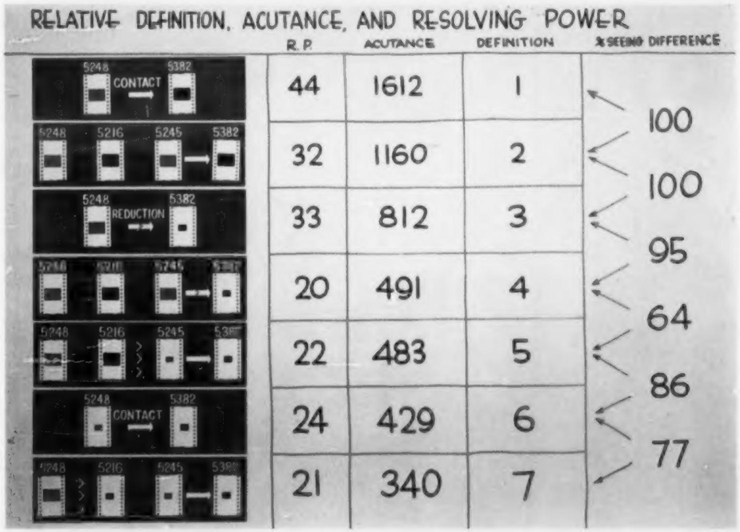

Fig. 8. Graphical description of printing processes studied.

Depth of Field and Perspective Considerations in Wide-Screen Cinematography

By ROBERT N. WOLFE
and FRED H. PERRIN

To improve definition in wide-screen cinematography, negatives are often made with a frame size larger than standard. The result is to decrease the depth of field in proportion to the first power of the linear dimensions of the negative unless the lens aperture is made smaller. This reduction in depth is less than when a close-up is made on a standard negative with the same camera magnification, in which case the loss is proportional to the square of the camera magnification; it is for this situation that the usual tables are computed. The depth of field can be restored by increasing the *f*-number correspondingly in any case, but this introduces lighting problems. Increasing the size of the screen without changing the size of the negative also decreases the depth of field proportionately to the increase in screen size. This effect is superposed on the change in depth of field arising from a change in negative size.

As DESCRIBED in the preceding paper,[1] it has been confirmed by controlled experiments that definition and graininess on the screen are notably improved by making a negative that is larger than standard and then projecting it at the normal screen size. The test object used for these experiments, however, was a scene in a single plane perpendicular to the optical axis. The purpose of the present paper is to show what happens when the scene is three-dimensional, that is, when some elements are nearer to the camera or farther from it than the plane on which the camera is sharply focused. The subjects involved in this paper are thus depth of field and perspective. Since the scene will be reproduced in only two dimensions, no problems of stereoscopy enter. Notwithstanding this restriction of the subject matter, only a few features of the greatest interest can be considered in the present brief treatment.

Magnification

To avoid confusion, the terms that are used must be specified exactly. In Fig. 1 the camera is focused on an object of height y at a distance s and the resulting image in the negative has a height y'. When the negative is printed, the image on the print has a height y'', and when the print is projected, the height of the image on the screen is y'''. The camera magnification m_c is approximately equal to the focal length of the camera lens f divided by the distance s from the camera to the point in the scene on which the camera is focused, or

$$m_c = y'/y \cong f/s. \qquad (1)$$

The values of the linear magnification in the printer and in the theater, respectively, are

$$m_p = y''/y' \text{ and } m = y'''/y'',$$

but since we are not interested in these individual values, we shall define a term "enlargement" by the equation

$$m_e = m_p m_t = y'''/y'. \qquad (2)$$

The overall linear magnification from scene to screen is then

$$m = m_c m_e. \qquad (3)$$

Perspective

When the scene is photographed, the camera is presumably placed so that a certain desired effect of perspective is produced, and if the scene were reproduced at its natural size on the screen this same effect of perspective would be experienced by an observer at the same distance s from the screen. To see what happens when the overall magnification is not unity, consider Fig. 2, which is copied in part from Fig. 1. The angle α subtended at the camera by the original object is approximately proportional to y/s. The angle α' subtended by the image on the screen when the observer is at a distance v is likewise approximately proportional to my/v. The condition for making α' equal to α is obviously that

$$v = ms. \qquad (4)$$

The perspective is then correct for objects on which the camera was focused, and a

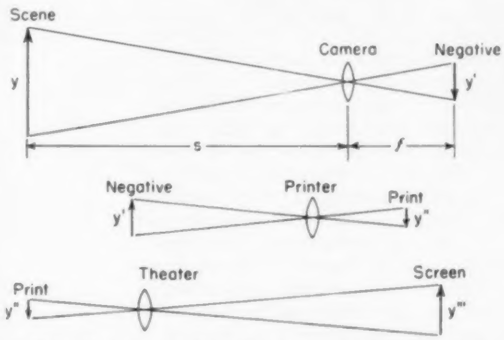

Fig. 1. Magnification relations in camera, printer and theater.

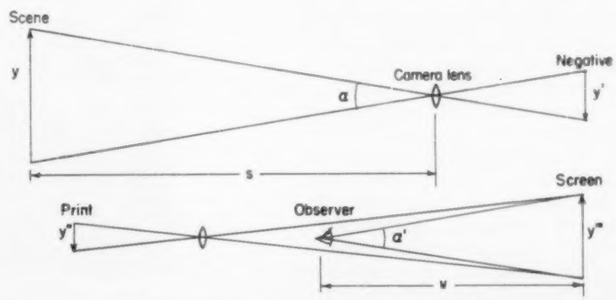

Fig. 2. Perspective relations between the camera and the observer in the theater.

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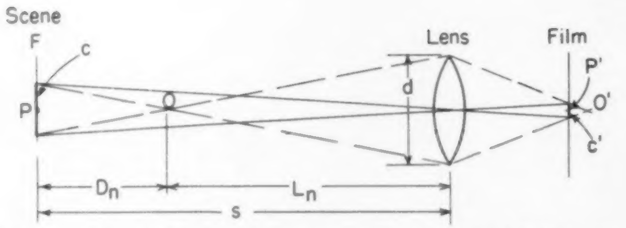


Fig. 3. Diagram to illustrate derivation of equation for depth of field on near side.

more elaborate analysis would show that it is also correct for all the other objects in the three-dimensional scene. It may be that no seat in the theater will satisfy this condition, and indeed it may even be that a conscious attempt was made to produce an effect of distorted perspective when the scene was photographed. The importance of this equation for our immediate purpose is as a yardstick to measure the constancy of the perspective. That is, we have the rule that *the perspective for any given observer is unchanged if the product* ms *is unchanged;* if this product equals the distance from the observer to the screen, the perspective is additionally correct *in the sense that the angular relations of the objects on the screen are the same as they would have been for the original objects in the scene had the observer been standing at the camera.*

Depth of Field

The formulas relating to depth of field are more complicated than those relating to perspective, and have frequently been misinterpreted. Indeed, confusion sometimes starts with the definition of the term itself. In optical theory, *depth of field* is the distance along the optical axis in the object space over which objects are in tolerably sharp focus under the given conditions of observation. The term "depth of focus" has frequently been used synonymously, but, in optical theory, *depth of focus* relates to the maximum permissible displacement of the film from the plane of true focus when the entire scene is in a plane perpendicular to the lens axis. It is true that the pattern of the circles of confusion that limit the depth of field can be transferred to the image space and the pattern of the circles that limit the depth of focus can likewise be transferred to the object space, but depth of field and depth of focus themselves are different concepts. Depth of focus is measured in microns; the depth of field is frequently infinite. We shall be concerned here solely with depth of field.

As the overall magnification is increased, even the objects on which the camera was focused will eventually become perceptibly unsharp. Although this probably takes place in cinematography under certain conditions, such situations cannot be discussed in a paper of the present compass. We can consider only the conventional case, for which the objects in the plane of best focus are reproduced so sharply that the observer would not be aware if any improvement were made. In Fig. 3, a lens whose entrance pupil has a diameter d is focused on an object plane F at a distance s. A point P in this plane is imaged sharply on the film at P'. On the other hand, a point O nearer to the lens than P would be imaged at O' if it were not intercepted by the film; actually, it forms a disk of diameter c' on the film. From the standpoint of the photograph, this disk is the image, not of point O at the distance L_n, but of a disk having a diameter c in the plane F on which the camera was focused. Simple geometry shows that

$$D_n = \frac{cs}{d + c}. \tag{5}$$

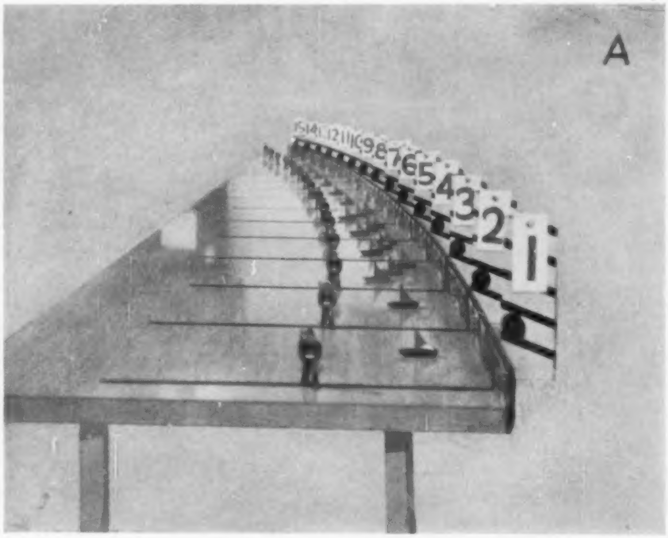


Fig. 4a. Photographs illustrating effect of

If the diameter c is assigned a certain critical value that will be specified shortly, the quantity D_n is defined as the *near depth of field.* An analogous argument for another point beyond the plane F would show that the *far depth*

$$D_f = \frac{cs}{d - c}, \tag{6}$$

so that the *total depth*

$$D = D_n + D_f = \frac{2csd}{d^2 - c^2}. \tag{7}$$

The quantity c is the diameter that corresponds in the scene to the maximum circle of confusion on the screen that the observer will tolerate as the image of a point. If c^2 is small compared with the square of the linear diameter of the lens stop d^2, it can be neglected and Eq. (7) can be written as

$$D = \frac{2cs}{d}. \tag{8}$$

This is usually the case for paper prints, but in cinematography, many theater seats are so far from the screen that the permissible circle of confusion in the scene may be even greater than the diameter of the camera lens. An example will be given at the end of the paper.

The quantities appearing in Eq. 8 are not the most convenient ones for computation and analysis, because those quantities rarely represent the known data, and it is desirable to make two substitutions. The first substitution is the f-number, N, in place of the diameter of the entrance pupil d, which is simple since $d = f/N$, where f is the focal length. The second is the diameter $c'' = mc$ of the maximum circle of confusion on the screen that the observer will tolerate as the image of a point instead of the diameter c of the corresponding circle in the original scene. The diameter c'' of this circle on the screen equals the product of the overall magnification m and the diameter c of the corresponding circle in the scene. With these substitutions, Eq. 8 becomes

$$D = \frac{2sc''N}{fm}. \tag{9}$$

The value of c'' is the product of the viewing distance v and the minimum angle θ in radians that a circle can subtend at the eye and still be practically indistinguishable from a point. This angle may be taken as 1/2000 radian for critical work, while the more liberal value of 1/1000 is commonly taken.

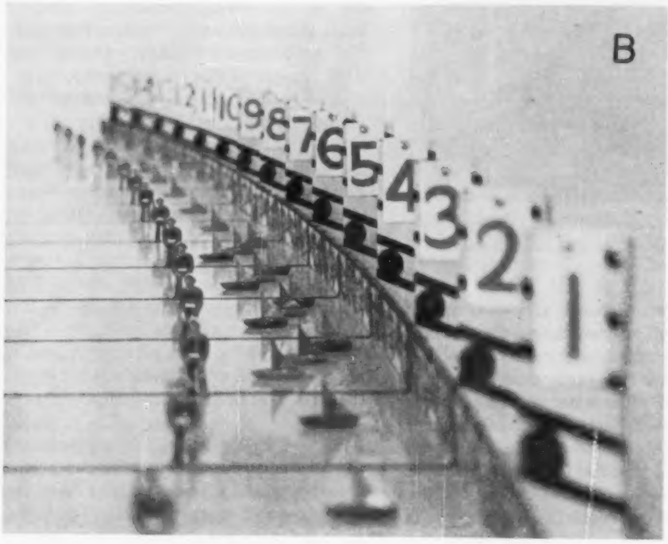
Of the formulas just discussed, the following three are basic:

Camera magnification, $m_c = f/s;$ (1)

Overall magnification, $m = m_c \cdot m_e;$ (3)

Total depth of field, $D = \dfrac{2sc''N}{fm}.$ (9)

All the cases to be discussed can be treated by suitable combinations of these equations. These cases obviously do not exhaust the situations that can arise in various types of photography, and other cases are considered in other treatments.[2]



varying the optical conditions on depth of field.

The Close-up

Let us consider first the common case in which a close-up is being made. This means that the image on the negative must be increased in size, although of course a smaller part of the scene is reproduced on the screen. The required increase in camera magnification can be accomplished either by using a lens of increased focal length or by moving the camera closer to the scene, since the enlargement between negative and screen is constant. The effect on the depth of field can be seen by combining the three basic equations and writing the result as

$$D = \frac{2c''N}{m_e} \cdot \frac{1}{m_c^2}. \tag{10}$$

The first factor contains only the quantities that are held constant in the case at hand; these are the diameter of the maximum permissible circle of confusion c'', the f-number N, and the enlargement m_e. The other factor contains only the camera magnification m_c, which is the variable in the present instance, and it is immediately evident

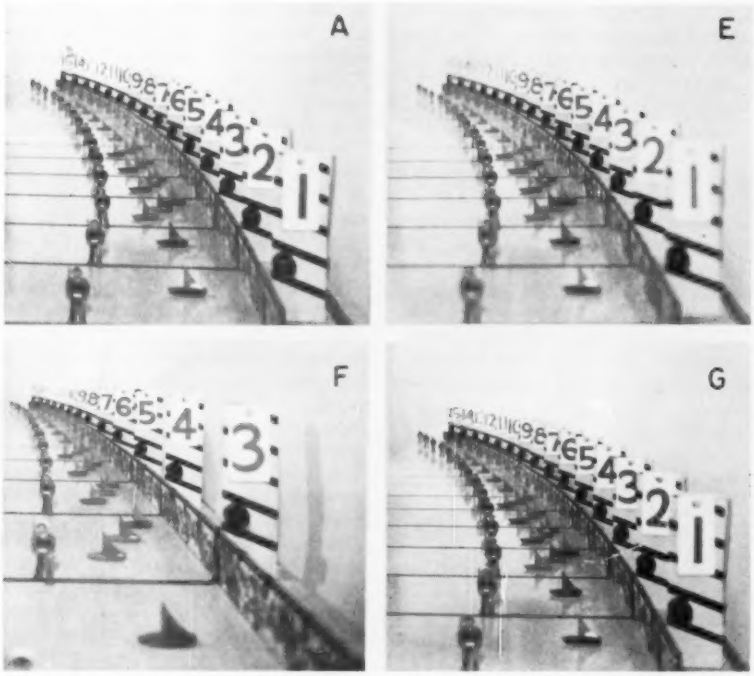


Fig. 4b. Photographs illustrating effect of varying the optical conditions on depth of field. Picture A is repeated from Fig. 4a but cropped to the size of the others.

that the depth of field varies inversely as the square of the camera magnification. If the heroine's head is tripled in size on the screen, then the depth of field is reduced nine times. The tables in the *American Cinematographer Hand Book*[3] bear out this ratio. Pictures* A and B in Fig. 4a show what happens when a lens of greater focal length is used. Picture A is the normal picture with which the others will be compared, while B represents the close-up. In both cases, the camera was focused on target 5. The field of Picture B is obviously much shallower than the field of the normal picture shown at A. Since the camera was not moved, the viewpoint of the two pictures is the same, but the overall magnification is different and thus the perspective is also different. If an observer was sitting where he saw the screen in the way the camera saw the original scene when Picture A was made, he would be too close when the lens was changed to increase the magnification for Picture B.

Picture C shows the effect when the camera is brought closer to the scene, as in a dolly shot, so that target 5 has the same size as in Picture B. Here the magnification m increases compared with Picture A as the camera-to-scene distance s decreases, and thus the product ms is constant; the perspective is the same for both pictures, and an observer at a distance ms from the screen sees the pictures exactly as the camera saw the original scene in both cases. On the other hand, the viewpoint has been changed; the effect on the observer is exactly as though he had walked closer to the scene. The field of the larger picture is shallower, but by practically the same amount as when the focal length of the lens was changed (Picture B), so the choice of the means to be used for making the close-up principally depends on the artistic effect that is desired.

It should be pointed out that, since the enlargement between negative and screen is the same for all three pictures, A, B and C, the maximum tolerable circle of confusion on the negative is also constant, and this is the condition for which the tables in the *Hand Book* were computed. It cannot be emphasized too strongly that these tables apply to this condition alone, and that whenever the enlargement between negative and screen varies, it is necessary to resort to the formula.

The Large Negative

Now suppose that a given scene is to be reproduced on a given screen so that the overall magnification is constant, but in one case a standard negative is to be used while in the second case a large negative is to be used. The enlargement between negative and screen must also vary, of course. Increasing the negative size means increasing the camera magnification, and this can be done by either using a camera lens of greater focal length or bringing the camera closer to the scene, as in the previous situation. The basic formula gives

$$D = \frac{2c''N}{m} \cdot \frac{s}{f} = \frac{2c''N}{m} \cdot \frac{1}{m_c} \qquad (11)$$

for the depth of field, which means that the field becomes shallower by the same amount whichever procedure is followed. In other words, the depth of field is inversely proportional to the camera magnification, regardless of the means by which this magnification is changed. But there is a sharp distinction between this case and the preceding one, namely, that the depth of field is affected only as the first power of the camera magnification and not as the square. Picture E in Fig. 4b shows what happens when the focal length of the camera lens is increased, compared with the lens used for Picture A. (A in Fig. 4a and Fig. 4b are identical.) It will be seen that, although the field of E, where the lens of longer focal length was used to make a larger negative, is shallower than that of A, the difference is much less marked than for the preceding case, Picture B, where the longer focal length lens was used to make the same size negative. Since the distance of the camera from the scene was the same for both pictures A and E and the overall magnification is the same, they both appear under the same perspective.

Picture F is exactly analogous except that the focal length of the camera lens was the same for both A and F, but the camera was brought closer to the scene to make a larger negative. The loss in depth of field is sensibly the same as before but the change in perspective is marked. Since m is the same while s is different, an observer who is properly seated to observe Picture A as the camera saw the original scene is wrongly placed for F, or vice versa. In addition, the viewpoint is different because the camera was moved.

A more elaborate mathematical analysis shows that when the permissible circle of confusion is large compared with the entrance pupil of the camera lens, the depth of field is reduced differently, by bringing the camera closer to the scene, from what it is when the focal length of the camera lens is increased, but the magnitude and even the sign of this effect depend upon conditions that would require another paper to discuss.

The Effect of Aperture Size

It has been tacitly assumed up to this point that the relative aperture of the camera lens was constant, and the question naturally arises whether the depth of field can be restored by reducing the relative aperture, provided, of

* All the pictures used to illustrate this paper were made by R. L. Lamberts, of these Laboratories, and it is a pleasure to acknowledge his skill and the care he took in preparing suitable examples.

course, that adequate light is available. Reordering the terms of Eq. (11), we get

$$D = \frac{2c''}{m} \cdot \frac{N}{m_c}, \tag{12}$$

which indicates that the depth of field remains constant if the f-number N of the camera lens is varied in proportion as the camera magnification is varied. Picture G was made with a camera lens having twice the focal length of the lens used for A so that m_c was twice as great and thus the negative was twice as large. Furthermore, the lens for G was stopped down so that its f-number was twice as great. As can be seen, depth of field in both pictures is sensibly the same. A comparison with Picture E shows the improvement achieved by stopping down the lens, since this pair of pictures was made in exactly the same way except that the aperture for E was twice as large as for G.

The Large Screen

Finally, let us consider the case of the large screen. If a given scene is to fill a larger screen, the same negative can be used with an increased enlargement (as by using a projection lens of shorter focal length) or a larger negative can be made and enlarged by the same amount on the screen. The simplest way of seeing the depth-of-field relations is to rewrite Eq. (10) as

$$D = 2c''N \cdot \frac{1}{m_e m_c^2}. \tag{13}$$

When a given negative size is used, m_c is constant and the depth of field varies inversely as the enlargement m_e from negative to screen. On the other hand, when the enlargement m_e from negative to screen is held constant but the increased screen size is obtained by increasing the negative size (increasing m_c), the depth of field varies inversely as the *square* of the negative size.* The first situation is exemplified by picture D in Fig. 4a, which is simply a greater enlargement of the same negative used to make Picture A. The loss in depth of field compared with A is obvious. The second situation is exemplified by a comparison of Picture B with Picture D. Picture B shows the result of using a larger negative to cover the larger screen, as compared with Picture D, which was made by increasing the enlargement of the smaller negative. Since the overall magnification m is the same for both B and D, as also was the camera distance s, both the perspective and the viewpoint are the same. The field of B, which was made from the larger negative, is clearly shallower than the field of D. Furthermore, this loss in depth of field associated with the use of the larger negative is additional to the loss associated with the larger screen, as shown by a comparison of B with A.

Conclusions

The conclusions of this analysis can be summed up by the numerical examples given in Table I, where it has been assumed that the camera was focused on a plane 30 ft distant. For the conditions taken as a basis of comparison, represented by the first line of the table, the camera lens was assumed to have a focal length of 2 in. and a relative aperture of $f/2$. It was further assumed that the 5-ft heroine is represented as being $2\frac{1}{2}$ ft high on the screen, in which case the magnification between negative and screen is such that a circle of confusion 1/500 in. in diameter on the negative, for which the *Hand Book* tables are computed, leads to a circle on the screen that subtends the reasonable angle of 1.7′ of arc (1/2000 radian) for an observer 30 ft distant. The depth of field is then about 25 ft for an observer at this distance, which is confirmed by the *Hand Book*. When a close-up is made by doubling the focal length of the lens so as to double the size of the heroine's face on the screen, the field is reduced in depth to about $5\frac{1}{2}$ ft. This reduction is roughly proportional to the square of the ratio of the focal lengths. The last two columns show that the original depth of field can be restored by diminishing the aperture (increasing the f-number) in proportion to the square of this ratio. When the lens of greater focal length is used to make a large negative that is printed or projected so as to fill the same screen as the standard negative, the depth of field is reduced to about half of its value for the standard negative (instead of one-quarter) and the original depth is restored by reducing the lens aperture (increasing the f-number) in proportion to the first power of the ratio of focal lengths (instead of the square). The maximum permissible diameter of the circle of confusion on the negative is doubled, and hence the tables in the *Hand Book* no longer apply.

The conclusions discussed so far relate to the making of the negative when the screen size is constant. When the screen size is varied so that the enlargement m_e varies, the depth of field varies according to the relation

$$D = \frac{2c''N}{m_c^2} \cdot \frac{1}{m_e}, \tag{13'}$$

which is simply Eq. (13) rearranged to emphasize the effect of varying m_e. Assuming that the entire frame of the release print just covers the screen, this formula means that *the depth of field decreases in direct proportion to any increase in the size of the screen.*

Discussion

An effect that frequently introduces confusion should be mentioned here. Suppose that, in a battle scene, the depth of field on the classical geometrical basis that has been used here is infinite. Then as a cavalryman gallops into the distance on his dapple-gray mount, the spots on his mount eventually disappear, but simply because they become too small to be reproduced distinguishably by the photographic system. If the definition of the system is improved, the cavalryman can gallop farther before the spots disappear, and in this sense, objects are reproduced more clearly over a greater range of distances. One method of improving definition is to increase the size of the negative. This reduces the geometrical depth of field, as shown earlier in this paper, but the present example still applies if the scene still lies within the reduced depth of field. Nevertheless, this is a totally different effect from that which has been discussed in this paper and would be produced equally well if the galloping horse were replaced by an inflated rubber dummy that shrank in size while remaining stationary.

An exhaustive treatment of depth of field would include many considerations that have been ignored here. Such are (a) the value of the angle subtended by the largest circle of confusion that cannot be distinguished from a point, (b) the possible variation of this angle with viewing conditions and (c) the angle subtended by the largest tolerable circle when the objects in the plane of best focus are perceptibly unsharp.

Within the limitations imposed by the

Table I. Numerical Example. Distance, camera to scene, 30 ft; observer to screen, 30 ft. This table has been computed with the complete formula, Eq. (7), containing the c^2 term in the denominator, and hence the uncompensated values do not bear the simple relations to focal length given in the text and listed here.

Negative size	Lens focal length, in.	Uncompensated: Lens f-no.	Uncompensated: Depth ft.	Uncompensated: Depth rel.	Compensated: Lens f-no.	Compensated: Depth, ft	Comp. factor
Standard	$f_1 = 2$	2	24.8	1	2	24.8	...
Standard (zoom)	$f_2 = 4$	2	5.4	$\frac{1}{4}$	8	24.8	$(f_2/f_1)^2$
Large	$f_2 = 4$	2	11.2	$\frac{1}{2}$	4	24.8	$(f_2/f_1)^1$

* To restore the original depth of field, the diaphragm of the camera lens must also be reduced in diameter by the square of the increase in the negative size, and hence, for a constant illuminance on the film, the illuminance of the scene must be increased by the *fourth* power.

assumptions made in this paper, the depth of field under various situations can be compared by using the formulas derived herein. Nevertheless, care must be taken to apply them properly. Suppose that the principal point of interest in a scene is 300 ft from the camera and that the resulting picture is to be viewed under the correct perspective by an observer 50 ft from the screen. The overall (scene-to-screen) magnification must then be

$$m = v/s = 50/300 = 1/6$$

by Eq. (4). The angle subtended by the maximum tolerable circle of confusion is commonly taken as 1/1000 radian, although this value is probably generous, so the diameter of the maximum tolerable circle on the screen can be taken as

$$c'' = v\alpha' = 50/1000 = 1/20 \text{ ft} = 0.6 \text{ in.}$$

The diameter of the corresponding circle in the scene is

$$c = c''/m = 0.6 \times 6 = 3.6 \text{ in.}$$

Now the stop of a motion-picture camera lens is smaller than this, so Eq. (7) for the total depth of field becomes negative. This is physically meaningless, but its mathematical significance can be seen, from Eq. (6), to be that the boundary of the far depth is beyond the horizon. Such a condition has been avoided in the illustrations presented here, but the example is cited to show that the formulas cannot be applied blindly. In this example, a clever cameraman would focus for a nearer distance, the so-called hyperfocal distance, such that the far boundary of the tolerably sharp field was just at the horizon and thus pull his entire useful field nearer to the camera and increase its useful depth.

As mentioned in connection with the large-negative case, using the simplified formula, Eq. (8), or its equivalent, Eq. (9), in place of the complete formula, Eq. (7), leads to the conclusion that the effect on the depth of field is the same whether the camera magnification is changed by varying the camera-to-scene distance or by using a lens of different focal length. This is often true closely enough, but it may be significantly in error when the projection of the maximum tolerable circle of confusion c in the scene is large compared with the stop diameter d.

References

1. G. C. Higgins, R. L. Lamberts and R. A. Purdy, "The effect on definition of the stage at which reduction is performed in reduction-printing processes," *Jour. SMPTE, 65:* 31–36, Jan. 1956.
2. R. Kingslake, *Lenses in Photography*, Garden City Books, Garden City, New York, 1951, pp. 10–21, 74–93.
3. J. J. Rose, *American Cinematographer Hand Book and Reference Guide*, American Cinematographer Hand Book, Beverly Hills, 1953, 8th ed., pp. 126–143.

Electronic Printing for 16mm Sound

By ROGER J. BEAUDRY

Electronic printing has been an important step in recent years in improving 16mm sound quality, particularly in Kodachrome and television films. Using variable density and supersonic bias, an electronic (or electrical) print shows increased signal level, increased signal-to-noise ratio and sharp decrease in intermodulation distortion. With good laboratory control and recording-equipment operational control, close tolerances can be achieved and maintained, thereby ensuring excellent and consistent quality.

THE NORMAL optical-printing method of obtaining 16mm release sound has always posed many problems. Some of these problems have been solved partially by using better recording equipment, maintaining printers at peak performance, using ultraviolet light in printers and maintaining close control of both negative and positive processes. Providing all the above precautions are taken, there still remain quality losses inherent in the process such as printer flutter due to improper sprocket-tooth contact, varying amounts of printer slip and loss of contact due to film-base shrinkage, loss of definition due to diffusion effects and increase in background noise due to print-through of negative grain. Chances of error in this process are rather high. If, for instance, either or both negative and print exposures are off tolerance (and either negative or positive processes), a variable-area track will have increased cross-modulation distortion showing up mainly as distorted sibilants, while a variable-density track will have increased intermodulation distortion caused by a nonunity print-through gamma.

The increased use of 16mm film for television has shown in more than enough instances the failings of the above process. While some prints have adequate quality, the average has succumbed to the chances of error. Even good 16mm prints show their inherent loss of quality when, for instance, a 16mm commercial is cut in with a live show or with a 35mm feature program.

Improvement Possibilities

While 35mm film is still the mainstay in large U.S. televising centers, 16mm is used throughout Canada and in many U.S. stations, and these will undoubtedly continue to use 16mm for some time to come, for economic reasons. *Therefore, an improvement will have to be made in 16mm sound quality.*

Two major improvements are now possible. The first, in order of quality, is of course magnetic recording on a striped release print where quality surpasses 35mm optical sound without any processing problems whatever. Since this process offers no laboratory problems and since quality is at its best, it would seem the logical solution. However, there seem to be some strong objections to this plan which, it is sincerely hoped, will be overcome very soon.

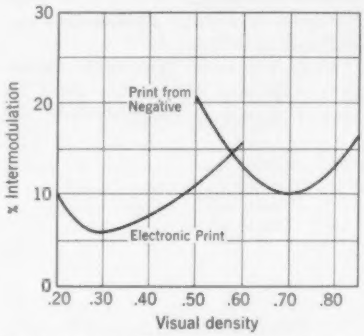


Fig. 1. Intermodulation characteristics for electronic and optical prints on black-and-white release prints (Eastman Type 7302).

The second solution to better 16mm sound quality is electronic printing, also called electrical printing. In this process the soundtrack is re-recorded as a positive image on each release print, thereby eliminating a good 75% of all normal 16mm distortion. The advent of magnetic recording has hastened the use of this process. Now, with good magnetic-recording systems readily available, it is possible to obtain top quality by using magnetic in all stages of production until the final transfer is made onto the release print itself.

Since only one photographic process is involved, laboratory control problems are greatly reduced and resolve themselves in keeping exposures constant and in keeping the release-positive process within even wider limits than required for good picture quality.

Figure 1 shows results of intermodulation tests made under SMPTE standards for both the negative/positive process and the electronic printing process. One observation from these tests is that intermodulation distortion is lower in the case of the electronic print, and the tolerances are wider. Another observation is, of course, the much lower density of the electronic print. This in effect means a considerable increase in projected light which results in increased volume of the modulation. Since intermodulation distortion is not at all critical, a print density can be chosen which, with the proper amount of d-c noise-reduction bias, reversed, will produce a high signal-to-noise ratio and also maintain a usable high-level output. A nominal amount of d-c bias is beneficial at the lower print densities but produces too much contrast at the higher densities where noise may be lower. However, by proper choice of these variables, an excellent signal-to-noise ratio can be achieved for a particular process.

After repeated tests in our studios the following results were obtained consistently without any extra laboratory controls over and above standard release controls, on 16mm black-and-white release prints:

- an increase in signal volume of over 6 db over the negative/positive process;
- a signal-to-noise ratio of 38 db;
- intermodulation distortion below 7%; and
- total flutter content below 0.15%.

The above results were obtained using variable-density recording with supersonic bias as described fully in previous papers.[1,2,3]

Electronic printing found its first practical use not for television films but for Kodachrome release printing. In the west coast area this process is in wide use and has been for some time. Everyone is familiar with the old problem of Kodachrome sound where a direct-positive black-and-white track is used as optical printing material. The biggest problems are low signal level, high background noise and very high distortion. By using variable density with

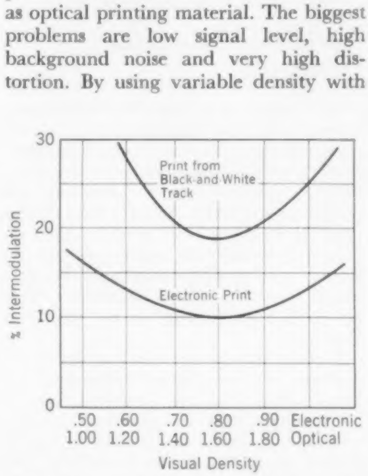


Fig. 2. Intermodulation characteristics for electronic and normal optical prints on Kodachrome release prints.

Presented on October 5, 1955, at the Society's Convention at Lake Placid, N.Y., by Roger J. Beaudry, Shelly Films Limited, Toronto, Canada. (This paper was received October 5, 1955.)

supersonic bias and noise reduction, great improvements can be achieved. The following are consistent results using this technique:

- an increase of over 6 db in signal level over the black-and-white optical-track printing process;
- a signal-to-noise ratio of 35 db;
- intermodulation distortion below 10%; and
- flutter below 0.15%.

Figure 2 shows results of intermodulation tests for both black-and-white track optical printing process and the electronic printing process. The two curves were placed so that the lowest intermodulation points are above one another. In this way it can be clearly seen that the electronic print curve is much lower and considerably broader than the optical print curve. Also, as in the black-and-white process, the optimum intermodulation occurs at a much lower density in the electronic print. Again this means increased volume. In the above technique, no filters are used in exposing the film. Results are so much superior to the regular printing process that no attempt was made to use filters. When filters are used to expose only one emulsion layer, focus of the optical recording system should be changed from the normal black-and-white position to assure good high-frequency response. It was not considered advisable to do this, since the same equipment is used for color and black-and-white.

While electronic printing is slightly more expensive to produce than the normal optical printing method, the improvements in quality more than make up the difference in bringing 16mm sound up to a level comparable with normal 35mm quality.

References

1. C. R. Keith and V. Pagliarulo, "Direct-positive recording," *Jour. SMPE, 52:* 690–698, June 1949.
2. John G. Frayne, "Electrical printing," *Jour. SMPTE, 55:* 590–604, Dec. 1950
3. James A. Larsen, "Improved Kodachrome sound quality with supersonic bias technique," *Jour. SMPTE, 57:* 60–62, July 1951.

Discussion

Frank P. Herrnfeld (Frank P. Herrnfeld Engineering Corp.): How was the last print through measured, by visual density?

Mr. Beaudry: Yes, it was visual density on an RA-1100-E densitometer, using yellow light. No attempt was made to use any color-correcting filters on the densitometer.

motion-picture standards

Revisions of American Standards

PH22.51, Intermodulation Tests, 16mm Variable-Density Optical Sound, a proposed revision of American Standard Z22.51-1946, is published here for a three month period of trial and criticism. All comments should be sent to Henry Kogel, SMPTE Staff Engineer, prior to April 15, 1956. If no adverse comments are received, this proposal will then be submitted to ASA Sectional Committee PH22 for further processing as an American Standard.

Review action on this standard was initiated by the Sound Committee in March 1952. The only comment received at that time was a suggestion that the references be either brought up to date or deleted from the standard entirely. The references were brought up to date in April 1953 and the standard was circulated to ASA Sectional Committee PH22 in May 1953 without prior publication for trial and comment since no fundamental changes were proposed.

At this point, a technical flaw in the 1946 standard was uncovered which necessitated returning the proposal to the Sound Committee for further consideration. This led to a very careful scrutiny of the standard by this committee and several drafts were voted upon before unanimity could be achieved. The proposal published here was approved by the Sound and Standards Committees and differs from the 1946 version in the following respects:

1. Revision of the title.

2. The first sentence of paragraph 1.1 has been modified to give a more exact definition of the scope.

3. The phrase at the end of paragraph 1.2, "but in most cases an intermodulation figure of 10 percent corresponds to a harmonic reading of about 2½ percent," has been deleted since this is true only under specific conditions.

4. The parenthetical phrase, "standard or nonstandard position" has been deleted from paragraph 2.1.

5. In paragraph 2.2 the words "color temperature of printer light" have been changed to "spectral energy distribution of printer light."

6. Also, in paragraph 2.2, a sentence has been added which provides a reference to additional sources of error.

7. Paragraph 2.3.1 has been changed because it specified a test signal of 60/100 cps, whereas neither of the previously recommended test equipments was capable of measuring a 60/100 cps signal.

8. A new paragraph, 2.3.3, has been added in order to specify a test track for the purpose of differentiating relatively uncontrollable intermodulation effects (as from printers) from those caused by the nonlinear relations whose control is the primary purpose of the intermodulation tests.

9. Paragraph 3.1 of the 1946 standard contained the statement that, "The com-

plete reproducing system should be checked for indications of distortion by use of a suitable test film, when available." No such test film was ever produced and since there is no likelihood that one will be produced in the near future, the phrase has been deleted.

10. Paragraph 3.3 has been completely reworded.

11. The reference to suitable intermodulation meters has been entirely deleted.

12. The list of references has been increased by five.

13. The term "intermodulation analyzer" has been substituted throughout for the term "intermodulation meter."

14. The abbreviation "cps" replaces the term "cycle" throughout.

15. The diagrams have been changed to conform to the new text.

Proposed revisions of American Standards **Z22.71-1950, 32mm Film for 16mm Film Perforated Along One Edge** and **Z22.72-1950, 32mm Film for 16mm Film Perforated Along Both Edges,** are published here for a three-month period of trial and criticism. All comments should be sent to Henry Kogel, SMPTE Staff Engineer, prior to April 15, 1956. If no adverse comments are received, these proposals will then be submitted to ASA Sectional Committee PH22 for further processing as American Standards.

In accord with ASA rules that all American Standards be reviewed every five years, these two standards were reviewed at the Film Dimensions Committee meeting held in Chicago on April 18, 1955. The following modifications of the 1950 standards were approved at that time and in subsequent voting of the entire committee and the Standards Committee:

1. The title was changed.

2. Method of indicating dimension G was modified to be in accord with international practices.

3. The letter symbols have been altered to give them an alphabetical sequence.

4. The appendix has been revised slightly to be in accord with recent changes made in such material in the other film-dimension standards.

	Dimension	*Was*	*Becomes*
5.	A	31.93 mm	31.928 mm
6.	B	0.300 in.	0.3000 in.
7.	C	1.83 ± 0.01 mm	1.829 ± 0.010 mm
8.	D	1.27 ± 0.01 mm	1.270 ± 0.010 mm
9.	R	0.25 ± 0.025 mm	0.25 ± 0.03 mm

The reason for changing dimensions B, C and D is to make the number of decimal places in the dimension and its tolerance consistent with one another and to make the degree of precision of the millimeter conversion the same as the inch dimension.

It should be noted that the conversion of the one mil tolerance of dimension A is maintained unchanged as 0.025 mm despite the fact that this makes the millimeter conversion more precise than the inch equivalent and is inconsistent with the tolerance for R in this standard and with this conversion in other standards. This problem was studied by the Film Dimensions Committee and it was decided that the 0.025-mm conversion should be maintained despite this inconsistency in order that the film, when slit, shall have a millimeter value consistent with practice abroad. If the 0.03-mm tolerance were used, this would result in too large an upper value. Since the tolerance is to be given in three places, it was necessary to specify the dimension itself to three places, even though it makes this value too precise. For similar reasons, 0.025 mm is maintained as the upper limit for dimension G.—*H.K.*

Two Proposed American Standards

Published here for a three-month period of trial and comment are two proposed American Standards, **PH22.106, Projector Aperture for 35mm CinemaScope Prints With Optical Sound** and **PH22.107, Film Spools for 8mm Motion-Picture Cameras.** All comments should be sent to Henry Kogel, Staff Engineer, prior to April 15, 1956. If no adverse comments are received, the proposals will then be submitted to ASA Sectional Committee PH22 for further processing as American Standards.

PH22.106 is based on Motion Picture Research Council Practice No. 3 which was submitted for Film Projection Practice consideration in April 1955. This was amended somewhat and then approved by this committee in October 1955 and by the Standards Committee in Dec. 1955.

Processing of PH22.107 was initiated by the 16 & 8mm Committee in October 1954. After study and ballot on two drafts, the proposal was approved by this committee in August 1955 and by the Standards Committee in November 1955.—H.K.

Standards Subscription Service

A valuable new Standards Subscription Service has been initiated by the Society for those who need an up-to-date record of SMPTE-sponsored American Standards and SMPTE Recommended Practices. Purchasers of this Service will receive, four times a year, copies of all standards approved during the preceding quarter. Charge for this January-December Service is $7.50 annually.

Arrangements have been made also for those who do not already have copies of all American Standards and Recommended Practices approved prior to December 31, 1955, to obtain them in a sturdy loose-leaf binder, plus the service for one year, for $27.50. And those who are uncertain as to whether or not their present files are complete may request, free of charge, the latest standards index and price list.

Standards subscription service order forms will be mailed in January to all Society members and to nonmember subscribers to the *Journal*. Additional or advance copies may be obtained from the headquarters office (55 W. 42 St., New York 36) upon request.

New President of ISO

Sir Roger Duncalfe became the fourth president of the International Organization for Standardization (ISO) on January 1st of this year. He succeeds Dr. Hilding Törnebohm, head of Swedish SKF.

Sir Roger served as president of the British Standards Institution from 1953 through 1955. He is chairman of the board of British Glues and Chemicals, Ltd., which produces half of the British output of gelatine and glue. He is a past president of the Federation of Gelatine and Glue Manufacturers and is a vice president of the Federation of British Industries. Sir Roger was knighted in the 1951 Birthday Honours for his services to standardization.

The first president of ISO was Howard Coonley, American industrialist. He was followed by Albert Caquot, distinguished French engineer. The ISO now has a membership of the national standards bodies of 37 countries. It was organized in London in 1946 as a successor to the prewar international organization which had been disbanded at the outbreak of hostilities.

The American Standards Association, of which SMPTE is a member, represents the United States in ISO.

Proposed American Standard

Intermodulation Tests, 16mm Variable-Density Optical Sound

PH22.51
Rev. Z22.51-1946

1. Scope

1.1 This standard defines the technique of measuring, by the intermodulation method, the sound distortion introduced during the processing of 16mm variable-density sound motion-picture release prints. Through measurements of distortion at various print densities, it is possible to choose a print density which will give sound prints having minimum distortion and hence optimum quality for the particular method of processing employed.

1.2 In general, the intermodulation method of measuring distortion differs from the harmonic method in that the former employs a low frequency and a high frequency at one fourth the amplitude of the low frequency, the combination being simultaneously recorded on the sound negative. Any distortion in the overall process causes a change in high-frequency amplitude in portions of the low-frequency cycle. The ratio of the average variation in amplitude of the higher frequency in the reproduced wave to its original amplitude is called the intermodulation. Intermodulation test results are not directly proportional to harmonic measurements.

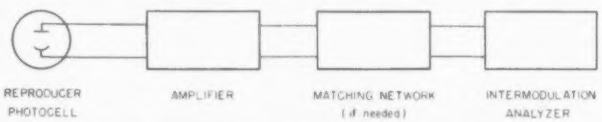


Fig. 1 Arrangement of intermodulation test apparatus to determine distortion on test track

2. Test Method

2.1 The test track, as described in 2.3, is recorded and developed under standard conditions for the process being checked, and a series of prints made at suitable printer lights to give a range of print densities for unmodulated, unbiased tracks above and below the expected optimum density. In most cases this will be in the density range from 0.4 to 0.7. There should be sufficient unspliced film ahead of the test track to permit stabilization of printer speed. The distortion content of the test-track print is then measured using equipment as shown in Fig. 1. In making the measurements, the test-track print is threaded through the soundhead of the film-reproducing device in the proper manner according to the position of the soundtrack. The distortion of each section of the print is then measured according to the operating instructions for the intermodulation analyzer used.

2.2 Since the method here described measures the overall distortion for a process involving numerous variables, each of which may affect the total distortion, it is necessary that all such variables (except the print density which is purposely varied to find the optium) in the recording and processing of the test track be maintained at the same values as they are normally in the process to be checked. These variables include film stock (both sound negative and print), recorder-lamp current, negative gamma, postive gamma, spectral-energy distribution of printer light, and type of printer (contact or optical). Any modulation in the amplitude of the higher frequency at a lower frequency rate, such as may result from variations in the degree of contact between negative and print in a contact printer, will be measured on an intermodulation analyzer. Every precaution should be taken to minimize such variations.

2.3 The test track shall consist of 2 sections, recorded in sequence at the same lamp-current setting.

2.3.1 Section 1 shall be recorded with a combination of 60 cps and 2000 cps having a peak amplitude 2.0 ± 0.5 db below full modulation, in which the 2000 cps level shall be 12 ± 1 db below the 60 cps level. The 60 and 2000 cps waves shall be not more than ± 3 per cent from the respective nominal frequencies and neither shall contain more than 5 per cent harmonic distortion. This portion of the track should be about 6 ft in length, 10 sec in running time. Conventional volume indicators do not indicate true peak values for complex signals such as the above combination of 60 and 2000 cps. The peak value of the complex signal will be 2 db below full modulation if the 60 cps alone is 4 db below full modulation.

2.3.2 Section 2 shall be at least 1 ft of unbiased, unmodulated track for density measurement.

2.3.3 It is recommended that from time to time a third section of test track be recorded. Section 3 shall be a recording made as for Section 1 but without the 60 cps signal for measurement of intermodulation other than that resulting from nonlinearity of the negative exposure print density characteristic.

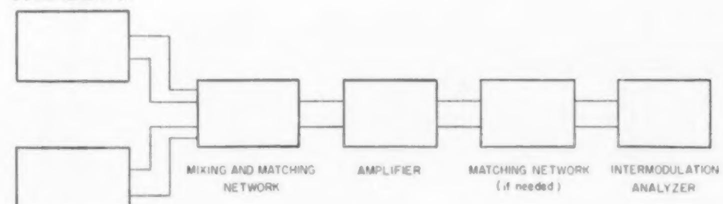


Fig. 2 Arrangement of intermodulation test apparatus to determine distortion in amplifier

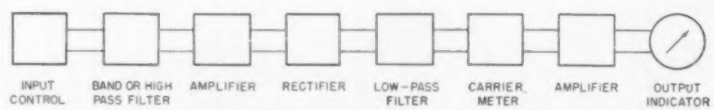


Fig. 3 Block diagram of intermodulation analyzer

NOT APPROVED

NOT APPROVED

3. Test Equipment

3.1 Reproducing System. Care should be taken that the reproducer photocell and its associated coupling circuit to the amplifier input tube do not introduce a significant amount of intermodulation. The complete reproducing system should be checked for indications of distortion.

3.2 Amplifier. The amplifier of the film reproducer in which the test strips are run shall not produce more than 2 per cent intermodulation when the intermdoulation frequencies are introduced directly into the input, as shown in Fig. 2, at approximately the same level as that used when measuring intermodulation on a film.

3.3 Intermodulation Analyzer. A block diagram of a suitable intermodulation analyzer is shown in Fig. 3. The intermodulation analyzer shall measure with frequency discrimination of less than ± 1 db an amplitude modulated signal for a side-band width within the frequency range of 2000 ± 400 cps. The direct application of the intermodulation analyzer to the test signal described under 2.3.1 shall result in an intermodulation reading of not more than 0.3%. A carrier level indication of 100% is desirable for a 2000 cps input level of not more than −10 dbm. It is recommended that the charge time of the rectifier circuit be in the order of 1 msec and the discharge time 100 msec. The accuracy of intermodulation indication shall be within 10% of meter full scale in the range of 5–15%. The intermodulation analyzer shall be calibrated using a sinusoidal modulation envelope within the frequency range of 60–120 cps and at an intermodulation level of not more than 10%.

References

Frayne, J. G., and Scoville, R. R., "Analysis and measurement of distortion in variable density recording," *Jour. SMPTE, 32:* 684, June 1939.

Frayne and Wolfe, *Sound Recording*, John Wiley & Sons, New York 1949 (chapter 21).

LeBel, C. J., "An experimental study of distortion," *J. Audio Eng. Soc., 2:* 215-218, Oct. 1954.

Macdonald, J. Ross, "The calibration of amplitude modulation meters with a heterodyne signal," *Proc. I.R.E., 42:* 1515-1518, Oct. 1954.

Read, G. W., and Scoville, R. R., "An improved intermodulation measuring system," *Jour. SMPTE, 50:* 162, Feb. 1948.

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NOT APPROVED

Proposed American Standard

32mm Film for 16mm Film Perforated Along One Edge

PH22.71
Rev. Z22.71-1950

1. Scope

1.1 This standard specifies the cutting and perforating dimensions of 32mm motion-picture negative and positive raw stock film.

1.2 This film is slit to become 16mm motion-picture film with perforations along one edge.

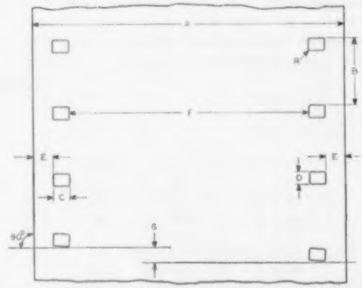
2. Dimensions

2.1 The dimensions shall be as specified in the diagram and table provided.

2.2 These dimensions apply to the material immediately after cutting and perforating.

2.3 In any group of four consecutive perforations, the maximum difference of pitch (dimension B) shall not exceed 0.001 in. and should be as much smaller as possible.

2.4 The length of any 100 consecutive perforation intervals shall be 30.00 ± 0.03 in., 762.00 ± 0.76 mm.



Dimensions	Inches	Millimeters
A	1.257 ± 0.001	31.928 ± 0.025
B	0.3000 ± 0.0005	7.620 ± 0.013
C	0.0720 ± 0.0004	1.829 ± 0.010
D	0.0500 ± 0.0004	1.270 ± 0.010
E	0.036 ± 0.002	0.91 ± 0.05
F	1.041 ± 0.002	26.44 ± 0.05
G	Not > 0.001	Not > 0.025
R	0.010 ± 0.001	0.25 ± 0.03

APPENDIX

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but since film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the slitters, punches and dies. Film can shrink or swell due to loss or gain in moisture content or can shrink due to loss of solvent. These changes invariably result in changes in the dimensions during the life of the film. The change is generally uniform throughout a roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important. This is one of the reasons for the method of specifying uniformity in dimension B.

Thirty-two-millimeter release-print stock in slit, after printing and developing, to 16mm width. Since a possible error is involved in this slitting, the width of 32mm film is made 0.001 in. narrower than twice the width of standard 16mm film. This narrowing gives a tolerance of 0.001 in. in this secondary slitting operation. If the error of slitting exceeds this tolerance, one of the 16mm halves may exceed the width allowed for 16mm film and cause interference in the gate of a projector. In addition to errors of centering, there are errors caused by recurring variations in width. These errors will cause weave on the screen even though the maximum width of the film may not be great enough to cause interference in the projector gate.

NOT APPROVED

Proposed American Standard

32mm Film for 16mm Film Perforated Along Both Edges

PH22.72
Rev. Z22.72-1950

1. Scope

1.1 This standard specifies the cutting and perforating dimensions of 32mm motion-picture negative and positive raw stock film.

1.2 This film is slit to become 16mm motion-picture film with perforations along both edges.

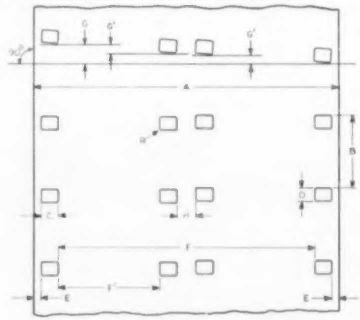
2. Dimensions

2.1 The dimensions shall be as specified in the diagram and table provided.

2.2 These dimensions apply to the material immediately after cutting and perforating.

2.3 In any group of four consecutive perforations, the maximum difference of pitch (dimension B) shall not exceed 0.001 in. and should be as much smaller as possible.

2.4 The length of any 100 consecutive perforation intervals shall be 30.00 ± 0.03 in., 762.00 ± 0.76 mm.



Dimensions	Inches	Millimeters
A	1.257 ± 0.001	31.928 ± 0.025
B	0.3000 ± 0.0005	7.620 ± 0.013
C	0.0720 ± 0.0004	1.829 ± 0.010
D	0.0500 ± 0.0004	1.270 ± 0.010
E	0.036 ± 0.002	0.91 ± 0.05
F	1.041 ± 0.002	26.44 ± 0.05
F'	0.413 ± 0.001	10.490 ± 0.025
G	Not > 0.001	Not > 0.025
G'	Not > 0.001	Not > 0.025
H	0.071 ± 0.001	1.803 ± 0.025
R	0.010 ± 0.001	0.25 ± 0.03

APPENDIX

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but since film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the slitters, punches and dies. Film can shrink or swell due to loss or gain in moisture content or can shrink due to loss of solvent. These changes invariably result in changes in the dimensions during the life of the film. The change is generally uniform throughout a roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important. This is one of the reasons for the method of specifying uniformity in dimension B.

Thirty-two-millimeter release-print stock is slit, after printing and developing, to 16mm width. Since a possible error is involved in this slitting, the width of 32mm film is made 0.001 in. narrower than twice the width of standard 16mm film. This narrowing gives a tolerance of 0.001 in. in this secondary slitting operation. If the error of slitting exceeds this tolerance, one of the 16mm halves may exceed the width allowed for 16mm film and cause interference in the gate of a projector. In addition to errors of centering, there are errors caused by recurring variations in width. These errors will cause weave on the screen even though the maximum width of the film may not be great enough to cause interference in the projector gate.

NOT APPROVED

Proposed American Standard

Projecture Aperture for 35mm Cinemascope Prints with Optical Sound

PH22.106

1. Scope

1.1 This standard specifies the dimensions and location of the aperture of projectors used in the projection of 35mm CinemaScope motion pictures employing one optical soundtrack.

1.2 It is intended that this aperture will be used in conjunction with 35mm motion-picture film cut and perforated in accordance with American Standard PH22.1-1953, Dimensions for 35mm Motion-Picture Film, Alternate Standards for Either Positive or Negative Raw Stock or PH22.36-1954, Dimensions for 35mm Motion-Picture Positive Raw Stock.

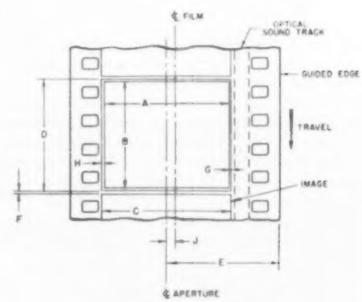
2. Dimensions

2.1 The dimensions of the aperture shall be as specified in the diagram and table provided.

2.2 Dimensions A and B are specified for an aspect ratio of 2.35:1 and for a projection angle of 0°.

2.3 Undersized apertures are required when the projection angle is greater than 0°, so that they may be filed to correct for keystone effect (see Appendix below).

2.4 It should be noted that the distance of the aperture centerline from the guided edge of the film is the same as for the 0.600 x 0.825 in. aperture specified in PH22.58-1954, Aperture for 35mm Sound Motion-Picture Projectors.



AS SEEN FROM THE PROJECTOR LAMP

Dimensions	Inches	Millimeters
A	0.839 max	21.31 max
B	0.715 max	18.16 max
C	0.868 min	22.05 min
D	0.735	18.67
E	0.738 ± 0.002	18.75 ± 0.05
F	0.013	0.33
G	0.008	0.20
H	0.021	0.53
J	0.049	1.24

APPENDIX

When the projection angle is greater than 0°, an undersized aperture must be used to make allowance for the kestone effect. This aperture would then be filed out to fit the particular projection angle. The bottom of this undersized aperture is filed out to the maximum width, 0.839 in., to obtain the necessary width at the top of the picture. The sides of the aperture are then filed to square off the picture. This results in dimension A being less than the maximum at all points other than at the bottom of the aperture.

When the projection angle is less than 0°, an undersized aperture also must be used to make allowance for the keystone effect. This aperture would then be filed out to fit the particular projection angle. The top of this undersized aperture is filed out to the maximum width, 0.839 in., to obtain the necessary width at the bottom of the picture. The sides of the aperture are then filed to square off the picture. This results in dimension A being less than the maximum at all points other than at the top of the aperture.

When a curved screen is used the aperture will also have to be undersized with respect to the B dimension to permit the filing of the top and bottom so that these edges of the picture will appear horizontal on the screen.

NOT APPROVED

Proposed American Standard

Film Spools for 8mm Motion-Picture Cameras

PH22.107

1. Scope

1.1 The dimensions shown in this standard are for 8mm motion-picture film spools with a nominal capacity of 25 ft. These spools are used in cameras of the type in which each roll of film is passed through the camera twice for exposure in accordance with American Standard PH22.21-1953, 8mm Motion-Picture Film, Usage in Camera (or latest revision thereof). The spindle holes in the spool are shown with splines which are intended to assist in assuring correct orientation of the spool in the camera.

2. Operation in Camera

2.1 When the spool is on the supply spindle, the flange with the 3-splined spindle hole, flange A, shall be on the lefthand side (as seen from the lens).

2.2 The half of the film adjacent to the flange with the 3-splined hole, when the spool is on the supply spindle, shall be in line with the camera lens.

2.3 When the spool is on the take-up spindle, the flange with the 4-splined spindle hole, flange B, shall be on the lefthand side (as seen from the lens).

2.4 When viewed from the lefthand side of the camera, both the supply and take-up spools shall rotate in a clockwise direction.

3. Dimensions

3.1 The dimensions shall be as given in the diagram and table.

3.2 If rivet heads or other fastening devices extend beyond the outer surface of the flange, they should lie within the zone indicated by diameters K and L and be no higher than indicated by G. It is not intended that this standard prescribe the nature or number of these fastening devices.

3.3 Dimension H is the space between the flanges at all points. At all points between the core and the periphery the tolerance shall be ± 0.006. Inside the core, the tolerance shall be ± 0.010.

3.4 Dimension J is the overall thickness (with the exception of the fastening devices) at all points between the spindle holes and periphery.

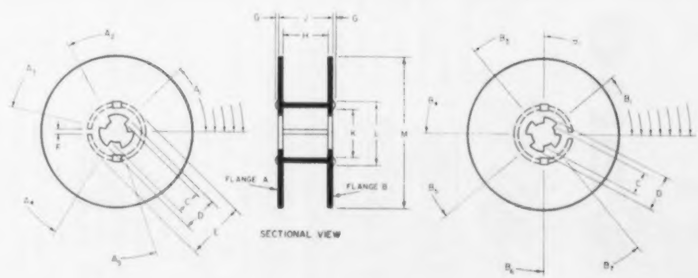
3.5 Dimension F specifies the width of slot in core for attaching end of film.

3.6 It is not intended that the relative orientation of the splines in the two spindle holes (or of the core slot) be specified or implied by this standard.

3.7 The following tolerance applies to the flatness and accuracy of rotation of both the internal and external flange surfaces, including rivets or other fastening devices. When the spool is rotated on an accurate, tight-fitting spindle, the maximum outward deviation from the intended plane for any point on the flanges shall not exceed 0.015 in., 0.38mm. The "intended plane" is defined as a plane normal to the axis of the spindle: for the outer surface of the flange, it shall be coincident with the surface of the flange over an area ½-in. in diameter centered about the spindle hole. For the inner surface it shall be coincident with the surface adjacent to the core.

Dimensions	Degrees
A_1	$39\frac{1}{2} \pm 2$
A_2	$120 \begin{smallmatrix}+2\\-0\end{smallmatrix}$
A_3	$159\frac{1}{2} \pm 1$
A_4	$240 \begin{smallmatrix}+2\\-0\end{smallmatrix}$
A_5	$279\frac{1}{2} \pm 1$
B_1	$39\frac{1}{2} \pm 2$
B_2	$90 \begin{smallmatrix}+2\\-0\end{smallmatrix}$
B_3	$129\frac{1}{2} \pm 1$
B_4	$180 \begin{smallmatrix}+2\\-0\end{smallmatrix}$
B_5	$219\frac{1}{2} \pm 1$
B_6	$270 \begin{smallmatrix}+2\\-0\end{smallmatrix}$
B_7	$309\frac{1}{2} \pm 1$

Dimensions	Inches	Millimeters
C	$0.288 \begin{smallmatrix}+0.007\\-0.004\end{smallmatrix}$	$7.32 \begin{smallmatrix}+0.18\\-0.10\end{smallmatrix}$
D	0.384 min	9.75 min
E	0.750 ± 0.015	19.05 ± 0.38
F	0.030 ± 0.015	0.76 ± 0.38
G	0.015 max	0.38 max
H	0.641	16.28
J	0.720 ± 0.010	18.29 ± 0.25
K	0.600 min	15.24 min
L	0.812 max	20.62 max
M	2.031 ± 0.015	51.59 ± 0.38



news and reports

Papers Program — 79th Convention

The schedule of sessions for the 79th Convention is about completed; and it appears as if there'll be a full and interesting program. This convention should produce a wide variety of papers as there is no single theme to which authors are limited. Sixteen technical sessions are planned, six of which will be held away from the Statler Hotel. These include a tour of Du Mont Telecenter, a demonstration of *Oklahoma* in Todd-AO at the Rivoli Theatre, a TV studio lighting session at the NBC Colonial Theater, and two sound recording sessions and a TV studio lighting session at Fine Sound Studios.

Of the sixteen sessions, present plans call for two on laboratory practice, five on television, three on motion-picture projection, production and viewing, two on high-speed photography, two on sound recording and one on screen brightness. Three of the five television sessions will be devoted to television studio lighting, treating the various problems encountered in lighting shows to be televised in black-and-white, and those to be televised in both monochrome and color.

Laboratory Practice sessions are planned for Monday, generally a light day in the laboratory, with the hope of encouraging large attendance from lab people in the New York area. Those coming from a distance should plan to stay around at least for Tuesday, when the Laboratory Practice Committee and the Association of Cinema Laboratories will both be holding meetings. Contrary to usual custom, sessions will start on Monday morning, before the luncheon; those attending should plan to get to the hotel in time to register before the morning session begins.

Evenings during the week have been planned for topics of more general interest such as the tour of the Du Mont Telecenter, not to mention the banquet on Thursday, to make it easier for accompanying wives and families to join in.

Author's Forms are now available and may be obtained from Society Headquarters, Program Chairman Ben Plakun at General Precision Laboratory, Pleasantville, N.Y., or from the following topic chairmen:

Laboratory Practice
W. H. Rivers
Eastman Kodak Co., Rm 626
342 Madison Ave., New York 17

Motion-Picture Projection, Production and Viewing
W. Borberg
General Precision Laboratory
47 Ossining Rd., Pleasantville, N.Y.

TV Studio Lighting
H. Gurin
National Broadcasting Company
RCA Bldg, Rm 586, Radio City
New York 10

Popular Papers
H. Barnett
General Precision Equipment Corp.
92 Gold St.
New York 38

High-Speed Photography
J. Waddell
Fairchild Camera & Instrument Corp.
88-06 Van Wyck Expressway
Jamaica 1, N.Y.

Sound Recording
G. Lewin
1573 East 35th St.
Brooklyn 34, N.Y.

TV General and Educational
S. W. Athey
General Precision Laboratory
47 Ossining Rd., Pleasantville, N.Y.

Screen Brightness
C. E. Heppberger
231 North Mill St.
Naperville, Ill.

Abstracts of all papers are due before March 1, with April 1 the deadline for completed copies of manuscripts. By this time, most of those intending to submit papers have probably already been contacted by their topic chairman, but if for any reason this has not happened they should go into action right away and get themselves Author's Forms.

SMPTE in 1955

By JOHN G. FRAYNE

The activities of the SMPTE during 1955 paralleled very closely the continuing widespread interest in new technologies in the associated industries. The problems associated with the introduction of the various wide-screen processes continued to absorb the interest of engineers and production personnel alike. Some of the developments engaging the interests of motion-picture engineers during 1955 are outlined below.

The CinemaScope system which had been introduced in 1953 continued to grow during the past year as evidenced by the reports on the number of theater installations in this country and abroad. However, this growth was mainly in the use of the anamorphic principle of photography and projection rather than in the use of the associated 4-track magnetic stereophonic sound. The decision of Twentieth Century-Fox to make a single optical track available appeared to halt, at least temporarily, the advance in the number of stereophonic installations in theaters. The recent announcement of the magoptical combination of 4-track magnetic stereo and single-track optical should tend to reduce the number of types of release prints and improve the compatibility of theater reproduction of magnetic and optical tracks. During the year, Twentieth Century-Fox announced improved definition in the 35-mm CinemaScope picture quality by the use of a larger production negative (55mm) as the photographic medium, thus meeting the objections widely raised as to the pictorial quality of CinemaScope films.

During 1955, Paramount reported several installations of their double-frame VistaVision system. The projectors are the horizontal type with standard 35mm film running at twice normal speed. The combination of the large VistaVision negative and the large print produces on the wide screen an image of excellent quality. It should be noted that these double-frame horizontal projectors are not compatible with standard 35mm projection. The sound system associated, up to the present time, with double-frame VistaVision is the single-optical variety, although it is understood that plans are underway for the addition of multitracks, either magnetic or optical. The higher linear speed of double-frame VistaVision prints opens new vistas of improvement for reproduction of either magnetic or optical tracks. These VistaVision installations have so far been limited to the small number of large theaters in the larger cities of the country.

The Todd-AO 65–70mm wide-screen system was first presented to the public in October of this year at the Rivoli Theatre in New York City. The camera negative employed in this system is 65mm wide and the release print width will ultimately be 70mm, added space being provided outside of each set of sprocket holes to permit the recording of six magnetic soundtracks. This system differs from other so-called wide-film, wide-screen systems in that the

projector built by the Philips Company, Holland, is said to be compatible with the projection of standard 35mm film. There are several innovations in the Todd-AO system, among them being the use of 30 frames/sec with the view to eliminating or reducing peripheral flicker. The projector is capable of running at the high speed required for the 70mm film or for the standard speed of 35mm film. The sound quality attained with the 6-track magnetic system in Todd-AO is generally agreed to be the finest recorded stereophonic sound yet presented to the public. Five loudspeakers are placed behind the screen, and in addition, speakers in the auditorium provide the surround sound effects. A novelty here is the close blending of the surround with the main sound channels. The problems of theater projection at severe angles onto the highly curved Todd-AO screen are presumably solved by specially pre-distorted prints. It is understood that this process has not yet been fully explored.

Of the Society's two Semiannual Conventions for 1955, the first was at Chicago in April where the employment of motion pictures in educational institutions and programs was emphasized. This drew a large attendance from the educational world which ordinarily would not patronize the Conventions of the Society. The Society had a very fine equipment exhibit also at the Chicago Convention. The Fall Convention was held at the beautiful Lake Placid Club, in Essex County, N.Y. This was the fourth convention held in that setting, the preceding one having been in 1950. During this Convention, very interesting roundtable discussions were held on the production of motion pictures in Hollywood studios with emphasis being placed on the problems involved in wide-screen color photography. Proponents of the various wide-screen systems were given opportunities to present their own views on their particular contributions. Another symposium was held on projection practices using wide-screen techniques. The chief engineers of the main television chains presented another very interesting roundtable devoted to the problems of the production and distribution of color TV programs.

The annual awards of the Society for outstanding achievement were presented at the Lake Placid gathering. This session was reported in the December 1955 *Journal*, pp. 689–694.

It was announced at Lake Placid that the Society had accepted the offer of Technicolor Corporation to present a gold medal, to be known as the Kalmus Award, each year to an individual for outstanding technical developments in the field of color cinematography.

The engineering activities of the Society continued to grow in scope during the year with all committees having very active agendas dealing mainly with standardization in the various fields of cinematography. The Society sent a very outstanding delegation to the International Standards Organization meeting at Stockholm in June. This delegation was under the general chairmanship of Dr. D. R. White of the du Pont's Photo Products Dept. Research Division. Other members of the delegation included Dr. Axel Jensen, Engineering Vice-President of the Society; Malcolm Townsley, member of the Board of SMPTE and Vice-President of Bell & Howell; and Boyce Nemec, Executive Secretary of the Society. During this very important meeting the groundwork was laid for future international standardization of many of the standards now being developed independently in the various countries.

During 1955 the Society's program for aiding in education of technicians in the motion-picture industry got off to a good start. One of the subcommittees, under the chairmanship of Sidney Solow, has been directly responsible for the introduction of three courses being given by the University of California Extension Division. These courses are slanted mainly towards laboratory personnel and the very large attendance and interest shown in these courses indicate the need for this kind of a program. It is hoped to extend the scope of this work to other technical groups, such as sound technicians, and also to make possible the presentation of similar courses in other parts of the country.

The membership of the Society increased during 1955 to an all-time high of 5587, while sustaining membership increased to a figure of 103. Several important changes to the Bylaws and Constitution were submitted to the membership. One of the most important of these was the creation of a new Vice-Presidency in charge of local sections. This move emphasizes the growing importance of the sections in the over-all program of the Society. A new section for the Rochester, N.Y., area was authorized during the past year.

The continued and rapid growth of the new technologies in the industry means, greater emphasis on the technical aspects of motion-picture production with consequent increasing demands for engineers skilled in these new techniques. This in turn insures the continuing growth and importance of our Society as well as an increasing impact of its programs on the motion-picture and television industries.

engineering activities

The beauty and charm of the Lake Placid Club, the color and warmth of the October foliage, the enticing golf course, tennis courts and hiking trails—none of these were enough to stop eleven engineering committees from holding their committee meetings on schedule, with a surprisingly large attendance and with an extraordinary amount of work accomplished. This report will attempt a general review of the deliberations of each committee.

Color

The work of this committee is, for the most part, done through its various subcommittees. One subcommittee, chaired by W. R. Holm, reported that the preparation of a monograph on "Elements of Color in Professional Motion Pictures" has been completed. It is tentatively planned to publish this work in booklet form as a *Journal* supplement.

Another subcommittee, with H. W. Knop as chairman, reported that the monograph on "Projection Light Sources and Screens for Color Films" is virtually completed. Completion is expected in the early part of 1956.

A third subcommittee, on "Densitometry of Color Sound Tracks," was formed, H. P. Brueggemann chairman. The initial aim of this group is to agree on a specific technique for the densitometry of sound tracks which can be adopted as the industry standard for color films.

Film Dimensions

The change in the film base over the years has resulted in a film with a constantly decreasing shrinkage characteristic. To compensate for this, both 35mm and 16mm film have been manufactured with a smaller pitch than specified in the existing standards. A standard to cover the situation already exists for 35mm film. At this meeting, note was taken of the volume of 16mm and 32mm on 35mm short-pitch film. It was felt that these films should be standardized and steps were taken to initiate this process.

The group viewed favorably the film-dimension concepts established at the ISO/TC 36 Stockholm meeting in June 1955 in respect to the desirability of one standard for all 35mm film. This would be done through the process of (1) tabling all data common to the differing 35mm films and (2) using a separate diagram and table to list the specifications for the differing perforations. A Proposed American Standard along these lines is to be drafted for consideration of the entire committee.

The titles of the existing film-dimension standards came up for critical examination and a subcommittee was formed, chaired by W. O. Brandsma, to prepare a consistent, concise and descriptive set of titles.

Film Projection Practice

This committee has been quite active in processing a rather large number of standards. The status of all these standards was reviewed and further actions were initiated to continue their processing. In outline form, this is the present status of this work:

PH22.104, Projector Aperture for 35mm CinemaScope Prints with Magnetic Stripes
PH22.105, Projector Aperture for 35mm Superscope Prints with Optical Sound
PH22.106, Projector Aperture for 35mm CinemaScope Prints with Optical Sound

Approved by Film Projection Practice and submitted to Standards Committee.

Z22.4-1941, 35mm Motion Picture Projection Reels

The first draft of the proposed revision of this standard was rejected by the committee. The discussion at this meeting laid the basis for a second draft to be prepared by F. H. Riffle, chairman of the subcommittee dealing with this question.

PH22.29 and .78, Screens and Mounting Frames for Theaters

Until now, these two have been separate standards. At this time, it was decided to combine them into one standard and to delete all reference to specific sizes of screens and frames inasmuch as the variety of existing aspect ratios precludes such standardization.

The effectiveness of heat filters in decreasing the destructive effects of film blistering was analyzed and W. R. Holm was assigned the task of making an experimental study of this question. Subsequent to the convention, he reported that with very rugged test conditions the use of a heat filter was completely effective in preventing film blistering.

High-Speed Photography

The prior nomenclature activity was reviewed in detail and Kenneth Morgan was assigned as coordinator to centralize the future work on this project.

The need for special standards for 16mm film for high-speed work was analyzed. The pitch of the perforations, the tolerance applied to this dimension and excessive film shrinkage were termed potential sources of trouble. R. D. Shoberg agreed to make a survey of high-speed camera users to determine the actual extent of these difficulties and whether official committee action is warranted.

Note was taken of the forthcoming Third International Congress on High-Speed Photography to be held in London, September 10–15, 1956, and of the requirement that papers to be presented there must be submitted by January 1956, since it is planned to pre-print all papers for use at the meeting. In addition, general plans were made for the high-speed sessions at the Society's 79th Convention.

Laboratory Practice

Two key activities have been under consideration for some time: (1) Printer Light Change Cueing of 16mm Negatives, PH22.89; (2) Nomenclature. The first involves experimental studies to establish a satisfactory method of cueing the light-change mechanism in the printing process so that notching the negatives for this purpose can be abandoned. Progress on these studies was reviewed and suggestions were made for completing this project. There was wide acceptance of the concept of employing a time-delay device so that the position of the cue spot could be standardized at or near the scene change; the ability to vary the time delay would permit the differing printers to make prints from the same cued negatives. A proposed American Standard is to be prepared incorporating this technique.

There are two aspects to the nomenclature project: One is the need to revise American Standard Z22.56-1947, Nomenclature for Motion Picture Film Used in Studios and Processing Laboratories, so that it is up to date; the second is the desirability of producing a more complete glossary of terms normally employed in the laboratory field. How to accomplish both of these objectives was the question and to this end specific forms were established and definite assignments were made to assure progress in both areas.

Brief consideration was given to the preparation of a second draft of a proposed standard on the aperture for 35mm contact printers and also to the need for developing a standard on glass electrodes along the lines of British Standard 2586, 1955. The former is to be circulated shortly for con-

sideration of the entire committee and C. F LoBalbo was assigned the task of ascertaining the need for the latter.

Screen Brightness

A varied and extensive program of work was reviewed in great detail:

Projection Screens. The Subcommittee on Projection Screens, chaired by Armin J. Hill, submitted a progress report dealing with classification of screens, definition of basic terms and recommendations on American Standards and two American War Standards relating to projection screens. The report and recommendations, with but a few modifications, were accepted with a commendation on the high quality of work and the subcommittee was directed to continue along the lines outlined in the report.

Drive-in Theater Survey. Additional data on this survey had been obtained. These data confirmed the general conclusions drawn from the earlier data, published in the July 1955 *Journal.* It was decided that it would be valuable to publish a brief report which would list the new data and its substantiation of the previously published material.

International Standard. William Kelley, a delegate to the Stockholm meeting of ISO/TC 36, summarized the discussions on screen brightness at that meeting and reported the agreements reached for preparation of a Draft ISO Proposal. A comparative analysis was made of the differences between the Draft ISO Proposal and the existing American Standard, PH22.39-1953. The effect of the new projection methods and resulting new, metallized screens was noted and the need for rapidly establishing standards for these screens was recognized.

U.S. Standards The foregoing discussion led to a review of the two American Standards on 16mm and 35mm screen brightness and to questions of desired objectives in improving these standards. A subcommittee was formed to give this further consideration and to make specific recommendations.

Meeting of C.I.E. Aspects relating to motion-picture work of the June 1955 Zurich meeting of the International Commission on Illumination (C.I.E.) were reported to the committee and discussed briefly.

16 & 8mm Motion Pictures

Consideration of nine standards occupied the center of interest of this group. The following conclusions were reached:

PH22.8, 16mm Film Projected Image Area
PH22.20, 8mm Film Projected Image Area
PH22.79, 16mm Sound Projector Test Film

These three proposals were approved for submittal to the Standards Committee for further processing.

PH22.7, 16mm Motion-Picture Camera Image Area
PH22.19, 8mm Motion-Picture Camera Image Area

An objection to the second draft of PH22.7 and an objection to the first draft of PH22.19 were debated and new drafts were agreed upon for consideration of the entire committee.

PH22.41, Optical Sound Record on 16mm Prints

An objection to the third draft of this proposal was not accepted and it was voted to ask the Standards Committee to continue its processing. It is expected that this proposal will be published for trial and comment in the February or March *Journal* along with introductory material explaining the nature of the controversy and the reasons for the accepted solution.

PH22.23, 8mm Projection Reels

The first draft brought forth several objections and a second draft is to be prepared which, it is anticipated, will resolve these objections.

Z22.80, Scanning-Beam Uniformity Test Film for 16mm Motion-Picture Sound Reproducers (Laboratory Type)
Z22.81, Scanning-Beam Uniformity Test Film for 16mm Motion-Picture Sound Reproducers (Service Type)

These are under review by a subcommittee working to reconcile discrepancies between the two standards.

Sound

Proposed American Standard PH22.40, Optical Sound Record on 35mm Prints, had been approved by the Sound Committee prior to this meeting. Based on a question from the British, in a letter referring to international agreements reached in 1952 in New York, the picture-sound separation specification of this standard was studied anew. This second look indicated that this could be clearer since it did not define the 20-frame separation as a print or a projector-threading specification. This problem was resolved by making a separate specification for each condition; and to improve further the clarity, explanatory material was added in an appendix to the standard.

The proposed American Standard on the four magnetic soundtracks for CinemaScope prints has run into difficulty. The sole area of controversy is the width of the effects track, track No. 4. This width was initially proposed as 29 mils but was changed to 41 mils in order to increase the playback level with the same signal-to-noise ratio. Opposition to the wider track was voiced in that it would probably increase the 96-cycles/sec amplitude modulation and appreciably reduce the tolerance between this track and the projector. This issue was not resolved and the question was therefore tabled for further consideration at the next meeting.

The results of the Stockholm meeting of ISO/TC 36 were reviewed in relation to the existing American Standards and the standards proposals in progress within the committee. This revealed several gaps in the committee's program of work, and action was initiated to fill these gaps.

Magnetic Recording Subcommittee

This committee discussed briefly questions relating to (1) batch identification of magnetic film; (2) 16mm multifrequency, signal level and azimuth test films; and (3) 16mm sound reproduce characteristics. The bulk of its time, however, was devoted to the question of the picture-sound separation on 16mm motion-picture prints with magnetic sound. Prior U.S. standardization had established the same separation, 26

frames, for both the magnetic and optical-photographic sound records. New technical developments, new uses of the magnetic sound record and differing practices abroad have sparked proposals that this specification be changed to 28 frames. While a consensus appears to favor this change, unanimity does not exist, and the pros and cons of 28 frames vs. 26 frames were discussed and analyzed in great detail. The question was not resolved, but the discussion provided an excellent foundation for further consideration.

Television

At the previous committee meeting, a subcommittee had been appointed to recommend the design of a gray scale for inclusion in color release prints intended for use on color television. The subcommittee submitted a progress report which, after study, was accepted as a valuable contribution to this project. The subcommittee was asked to continue its work and to field test the conclusions reached.

The relationship between the existing American Standard, 16mm Motion-Picture Television Projectors for Film Chains Operating on a Full-Storage Basis, PH22.91-1955, and the new developments in the television field was examined. This led to the appointment of a subcommittee, with H. N. Kozanowski as chairman, charged to write tentative standards of good engineering practice for 16mm projectors as applied to present-day pickup equipment and to study PH22.91-1955 with a view toward bringing this standard up to date.

PH22

PH22, ASA Sectional Committee on Motion Pictures, represents the U.S. on Technical Committee 36, Cinematography, of the International Standards Organization (ISO). Inasmuch as the second meeting of ISO/TC 36 was held in Stockholm in June 1955, PH22 devoted this meeting to analyzing the results of the Stockholm meeting and to establishing the requisite procedures for furthering this international standardization program.

A general outline of the ISO picture was submitted by D. R. White, chairman of PH22, for committee consideration. This report, as approved by the committee, was published on page 631 of the November 1955 *Journal*.—*Henry Kogel*, Staff Engineer

section reports

The Pacific Coast Section held its regular program meeting on December 20, 1955, in Radio Studio A of the American Broadcasting Company, Hollywood. Attendance totaled 210 members and guests.

The program was outstanding for materials, technique and presentation. A demonstration of the new Anscochrome reversal 16mm film was given by John Kowalak of Ansco. Sid Solow of Consolidated Film Industries presented a demonstration and discussion of the technique used in making 16mm Eastman color prints from original Kodachrome, using 16mm Eastman color negative as an intermediate. Carl Hauge, also of Consolidated Film Industries, described and demonstrated a highly novel visual scene counter for laboratory projection rooms. Fred Albin of ABC-TV. discussed the video recording technique as it has been modified and developed for Vidicon TV camera reproduction.

The Society is grateful to the American Broadcasting Company for again providing a Studio for our meeting, and to Cameron Pierce of ABC-TV for his cooperation in making the arrangements — *E. W. Templin*, Secretary-Treasurer, c/o Westrex Corp , 6601 Romaine St., Hollywood 38.

The Western New York Subsection of the Atlantic Coast Section announced new officers at the December 14, 1955, meeting held at Kodak Park, Rochester. The new officers are:

Chairman: A. C. Robertson, Eastman Kodak Co.

Secretary-Treasurer: George T. Negus, Eastman Kodak Co.

Program Chairman: Walter I. Kisner, Eastman Kodak Co.

Board of Managers:

Arthur E. Neumer, Wollensak Optical Co.
John L. Forrest, Ansco
Monroe E. Sweet, Consultant
David D. Manning, WHAM-TV

Biographical Note

Dr. C. E. Kenneth Mees, the internationally known scientist, retired on November 15, 1955, as Vice-President in Charge of Research for the Eastman Kodak Company. Dr. Mees continues as a member of the Board of Directors. He has taken up permanent residence at his home in Honolulu, Hawaii.

The son of a Wesleyan minister, Dr. Mees was born at Wellingborough, England, on May 26, 1882. He received a classical education but his interest in general science was aroused by a demonstration of the making of chlorine gas by a school instructor.

Although Dr. Mees' interest in science and photography dates from his early boyhood, he did not become interested in photographic science until after he entered University College, London. A short time previous to that, and while at St. Dunstan's College, he had met S. E. Sheppard. He and Sheppard often discussed what happened to a plate when it was exposed in a camera and developed to a negative. Their search of published information in the University College library, however, revealed very little until Sheppard came upon the classical paper by Hurter and Driffield, which had been published in 1890 in the *Journal of Chemical Industry*. This paper laid down the basic principles of photographic exposure and development. Using more refined apparatus built by themselves, Mees and Sheppard repeated and extended the work of Hurter and Driffield. The results were submitted to the examiners as theses for the B.Sc. degree by research, the first and last time such a degree was granted by London University.

Following the granting of the degrees to them in 1903, the two students continued their work on the theory of the photographic process and in 1906 published their researches jointly as a book, *Investigations on the Theory of the Photographic Process*. On the basis of this work, each was granted the Doctor of Science degree.

When he had completed this work, Dr. Mees said he thought he would like to remain at college as a teacher, but his professor, the great physical chemist, Sir William Ramsay, persuaded him to enter the field of industry where Ramsay said research workers were needed. He joined the small photographic firm of Wratten and Wainwright Ltd. at Croydon, England, in 1906 as a partner and joint managing director.

For six years, Dr. Mees worked at Wratten and Wainwright. His first important photographic achievement was to sensitize photographic dry plates in manufacture to light of all colors, and he thus produced panchromatic plates. He studied photographic sensitizing and the spectrophotometric characteristics of dyes, and worked out methods for the manufacture of light filters and safelights, special plates for photoengravers and spectroscopists, and did research on the resolving power of photographic materials. He had little time then to work on the basic theory of photography.

In 1912, at Mr. Eastman's invitation, he joined the Eastman Kodak Company and went to Rochester, N.Y., to organize and direct a research laboratory. In the years 1912–1913, the Kodak Research Laboratory was one of a small number of such laboratories in industries in the world. As a director of an industrial research laboratory, Dr. Mees pioneered. Furthermore, the Kodak Research Laboratory was one of the first in industry in the United States to conduct a program of fundamental research, which up to that time had been restricted almost exclusively to universities.

As originally organized by Dr. Mees, the Kodak Research Laboratory had three basic departments: chemistry, physics and photography. Fundamental and applied research has been conducted in all these fields of science ever since the formation of the Research Laboratory and nearly 1800 scientific communications from the Laboratory have been published in technical journals in many countries. Dr. Mees also initiated in 1915 the publication the *Monthly Abstract Bulletin* in which abstracts are published of articles on photographic and allied subjects from the world's literature. He established in the Research Laboratory a library that has grown into the most important one of its type.

During the forty-four years in which Dr. Mees was concerned with operations of the Research Laboratory at Kodak Park, he realized two of his life ambitions: (1) the development of a science of photography and (2) the application of science to industry. While considerable work of the Laboratory staff has been done on fundamental research in the theory of photography, much time has been spent on development of new processes and improvement of existing ones. The latter program has resulted in the introduction of new photographic materials for the amateur and the professional, the industrial worker and the scientist. Of widest popular interest perhaps was the introduction of 16mm Cine-Kodak Film and equipment in 1923 and of Kodachrome Film in 1935, on both of which research and development were initiated in the Kodak Research Laboratories.

Other significant developments under Dr. Mees' direction were: (1) the founding at Kodak Park in 1917 of the first school of instruction in aerial photography; (2) the establishment in the Laboratory in 1918 of a department for the manufacture of synthetic organic chemicals when the supply of such products from Germany was cut off during World War I; (3) the organization of a department in 1919 for the development of photographic apparatus; (4) the establishment in 1931 of a department of emulsion research which has made important contributions to the knowledge of emulsion manufacture; and (5) the establishment in 1934 of a department in the Laboratory to carry out research on cellulose ester yarn and plastics for the Tennessee Eastman Company.

Dr. Mees was named a director of the Kodak Company in 1923 and was elected Vice-President in Charge of Research and Development in 1934.

In the last half century, Dr. Mees has been prolific also as a writer, lecturer and world traveler. He has published nine books and some 160 scientific articles and pamphlets. For 34 years he has been a contributor to the *Journal* of this Society, his first paper in the *Journal* being one on color photography (May 1922). The greatest of his publications is his book *The Theory of the Photographic Process* published in 1942 and revised in 1954. His book *The Path of Science*, published in 1946, is an account of science for historians and of world history for scientists. With J. A. Leermakers, an assistant director of the Laboratory, he is coauthor of the book *The Organization of Industrial Scientific Research*, a complete revision of his book published in 1920 which was the first of its kind.

Dr. Mees' work has been recognized by awards and honors presented to him from societies and organizations in many countries of the world. That his work is valued on the highest level is evident from his being a Fellow of the Royal Society of London, a member of the American Philosophical Society, a member of the National Academy of Sciences, and a Fellow of the Society of Motion Picture and Television Engineers. He has been particularly interested in giving service to science, especially in fields where the special knowledge and experience of the Kodak Research Laboratories could be applied. In particular, he contributed very greatly to the recent advances in astronomy; he received the Henry Draper Medal for 1936 of the National Academy of Sciences.

The high regard in which he is held by his associates on the Board of Directors of the Eastman Kodak Company is well expressed in the following quotation from their tribute to him on November 15, 1955:

> "Many others have done him great honor which we cannot enhance, but we alone can give our personal testimony of appreciation and gratitude for the inspiration of his genius and leadership in Kodak affairs, and for the heritage of high aims and great accomplishment which he has left to us."

—*Glenn E. Matthews*

Obituary

Robert E. Shelby, a Fellow of the Society and Vice-President and Chief Engineer of the National Broadcasting Company, died unexpectedly in Teaneck, N.J., on December 6, at the age of 49.

A pioneer in the development of black-and-white and color television, Mr. Shelby had been associated with NBC since 1929. When the company first established its television development laboratory in the Empire State Building in New York in 1931, he was put in charge of the project, supervising the earliest experimental work in TV operation techniques.

From 1935 to 1937, he assisted in the organization of RCA-NBC field tests of all-electronic television and in the design of equipment and facilities for those tests. During World War II, Mr. Shelby directed NBC's wartime research and development activities, including the development of an airborne television reconnaissance system for the U.S. Navy. He also served during this time as technical consultant to the National Defense Research Committee.

Mr. Shelby participated actively for a number of years in the television standardization work of various industry committees. Before his promotion to Vice-President and Chief Engineer, he was director of Color Television Systems Development for NBC and in this post played an important role in the introduction of RCA-pioneered compatible color television.

He was elevated to the grade of Fellow in the Society on October 4, 1955, at the 78th Convention, Lake Placid, N.Y.

Education, Industry News

SMPTE to Compile Courses of Instruction Report

Formal steps have been taken by the Society to compile a report on motion-picture and television instruction in colleges and universities in the United States. Dr. John G. Frayne, SMPTE President, has appointed a Committee on College Motion-Picture and Television Curricula.

In 1946 Dr. Frayne compiled a report on motion-picture instruction in colleges and universities and in September 1950 this report was revised by Jack Morrison

of the University of California at Los Angeles. In addition to bringing those earlier reports up to date, the committee hopes to expand them to include related courses in television instruction.

The committee, which is under the chairmanship of Desmond P. Wedberg, Editor of *Film and A-V World*, is a subcommittee of the Society's Committee on Education. The parent group was organized early in 1955 to meet the growing need for trained technical people in the motion-picture industry. Through its subcommittee on Training of Film Laboratory Technicians the group has already established three seminars at the Engineering Extension Division of the University of California at Los Angeles.

Other members of the new committee are Dr. Herbert A. Berry, Gordon-Berry Scripts, La Mirada, Calif.; Herbert E. Farmer, University of Southern California, Los Angeles; Dr Charles Fermaglich, Empire Studios, Houston, Texas; G. B. Grossman, Hughes Aircraft, Culver City, Calif.; Haig P. Manoogian, New York University; Thomas W. McMaster, Edward Bok Vocational School, Drexel Hill, Pa.; Joan Reynertson, Alturas Films, Santa Barbara, Calif.; Emmett R. Salzberg, Circle Film Laboratories, New York City; Edgar A. Schuller, De Luxe Laboratories, Astoria, N.Y.; and George N. Woodruff, Chicago Midway Laboratories.—*S.G.*

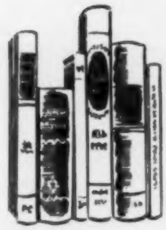
Sound Course

A course in the "Elements of Sound Recording for Motion Pictures," which will begin February 9 at the University of Southern California, has been sponsored by the Society through the Education Committee's Subcommittee on Sound Recording. Designed specifically for operating personnel in the Sound Departments of Hollywood film studios, this course was organized and developed by the Society, the engineers in the industry and the I.A.T.S.E. Sound Technicians, Local 695, to give the newer men in the field a background in the principles of sound and the procedures in its recording.

The course will cover present-day recording methods, materials, equipment and personnel; physical elements of sound and acoustics; production techniques; microphones, mixers, recording equipment and factors governing sound quality. It will be taught by Mr. Wiegand of the Department of Cinema faculty and by guest lecturers from the industry who are specialists in the various problems.

The class will meet Thursday evenings, Feb. 9 through June 7 at the Cinema Building, 659 W. 35 St., Los Angeles, from 7:30 to 10:10 P.M. The registration fee is $60.

The Subcommittee on Sound Recording is under the chairmanship of Lorin D. Grignon of Twentieth Century-Fox, and is comprised of representatives of the studios, USC and the union, including Lloyd T. Goldsmith of Warner Brothers, Fred R. Wilson of Samuel Goldwyn Studio, William Stafford of MGM, Herbert Farmer of USC, Tom Carman, business agent of Local 695, and Barney Freericks, Twentieth Century-Fox.—*S.G.*



books reviewed

Research Films in Biology, Anthropology, Psychology and Medicine

By Anthony R. Michaelis. Published (1955) by Academic Press Inc., 125 E. 23 St., New York 10. 490 pp. 87 illus. $5\frac{3}{4} \times 9$ in. Price $10.00.

Dr. Michaelis has produced a small encyclopaedia by strictly limiting it to research motion pictures in biology, medicine and the social sciences; excluding film strips, teaching films, etc. A second volume may be published on physical science, geography and engineering, and astronomy if there is sufficient interest. Workers in these fields should demand this aid.

"A research film results from the application of cinematography to the systematic search for new knowledge in the sciences." Some of us prefer to think of *science* as a unity with different approaches or branches rather than the categories of this book; some of which are rather small to be called sciences.

The first 32 pages are devoted to definitions, boundaries, history, literature, advantages and limitations, research films, cameras, chronometers, planning, analysis, use, preservation and storage of research films and stereoscopic photography in research. This compact treatment, as well as the rest of the book, reads well, First principles are stressed, little is missed, even a touch of calculus is shown to be useful in frame analysis. Historical treatment includes brief mention of Marey's work and specific references to other books and sources. While definitely a British book, the author has not restricted the content to works in one language. Camera needs are stated and referenced, but it is noted that none have been manufactured specifically for scientific use.

The rest of the book covers the Biological Sciences, with chapters on cinematography, biology and animal behavior; the Human Sciences which he treats with chapters on human record films, anthropology, and psychology and psychiatry; and the Medical Sciences with chapters on techniques of medical cinematography, techniques of X-ray cinematography and medicine. Each chapter starts with an argument and most chapters include theoretical and practical considerations, techniques, reviews and sources. The classifications and subdivisions will amaze many readers, e.g., muscular action receives equal billing with locomotion, botany, reproduction, cytology and embryology; X-ray cinematography is found under biology (circulation and heart) 3+ pp., as a chapter of 26 pp., and under medicine (heart) 3+ pp. Fortunately a

good index and analytical table of contents aid the reader to find that which interests him.

Technical methods and equipment are discussed at some length at the beginning of the biology section and again in each of the other sections. Special equipment is mentioned here and there throughout the book, often only in a sentence with a reference. Illustrations of more equipment would have been of aid to those entering this field. The less expensive and complex solutions will have to be dug out from the references; e.g., the delightfully simple focusing device of Krog's is not mentioned, although the reference is cited in the bibliography.

The bibliography of 1490 titles is quite complete and indexed as to where each is discussed in the text, an invaluable aid for workers in the fields of interests cited. Much general information is given as graphs showing the number of scientific films in several disciplines and several countries. Sources of films, catalogs and film libraries are listed for many countries. The biological section is quite complete, the medical section is less adequate and the human sciences interesting although I do not know how complete.

Dr. Michaelis is to be congratulated for a monumental task of analysis—truly *multum in parvo*. Brevity sometimes misses basic problems; for example, the reviewer notes on p. 55 that his own 1932 equipment is mentioned to condemn it, because the camera was removed for changing film. No credit is given to the fact that this was done in the darkness of the changing bag so that inexpensive, unspooled positive film might be used and the budget extended.

The fundamental accomplishment is the compact organization with good documentation of so much information. The book will be a first source to learn what scientific motion pictures have done and how research uses cinematography. The administrator and the scientist will find much information and guidance, whether they are looking forward or backward into history. The engineer may find enough information to set up equipment for a scientific investigation, and if not he can use the ample list of references in many languages—*O. W. Richards*, Research Supervisor for Biology, American Optical Co., Southbridge, Mass.

current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 36, Nov. 1955
Toughest, Thinnest Film (p. 646)
The Use of 'Existing Light' in Newsreel Photography (p. 648) *B. Gray*
Summary of Current Wide-Screen Systems of Photography (p. 654)
Synchronized Sound with Any Silent Projector (p. 662) *H. Benson*

American Cinematographer vol. 36, Oct. 1955
CinemaScope on 55mm Film (p. 582) *A. E. Gavin*
Gleason Goes "Live on Film" (p. 584) *L. Allen*
Preparation of 16mm Printing Leaders (p. 586) Assoc. of Cinema Laboratories, Inc.
Animation Major Factor in Production of TV Ad Films (p. 588) *V. W. Palen*
The Superscope Process (p. 591) *W. Cline*
Anscochrome Now Available in 16mm (p. 606)

British Kinematography vol. 27, No. 5, Nov. 1955
Supalux Projection System (p. 138)
Television Coverage of Great Britain (p. 139) *R. A. Rowden*

Electronic Engineering vol. 27, Dec. 1955
16mm Tele-recording for Sequential Television Systems (p. 516) *V. B. Hulme*

Electronic Engineering vol. 27, Nov. 1955
Colour Television in the U. S. A. (p. 488) *C. G. Mayer*

Electronics vol. 28, Dec. 1955
Automatic Colorimeter Checks TV Color Tubes (p. 138) *E. Sanford*

Institute of Radio Engineers, Proceedings vol. 43, Nov. Pt. 1, 1955
The ABC's of Television (p. 1574) *J. M. Barstow*

International Projectionist vol. 30, Nov. 1955
Proposed Magnetic-Optical CinemaScope Print (p. 10)

55mm CinemaScope Negative Will Improve Definition (p. 12) *A. Gavin*
Fast-Pulldown Intermittent Movements Solve Many Projection Problems (p. 13) *J. M. Ruiz*
Cronar, New DuPont Film Base, Soon to be in Production (p. 16)

International Projectionist vol. 30, Oct. 1955
The Todd-AO System: A Projector for Both 70- and 35mm Film (p. 7) *J. Morris*
SMPTE Survey of Drive-In Theatres (p. 13) *F. J. Kolb, Jr.*
Recent Trends in Shutter Design for Theatre and TV Projection (p. 17) *R. A. Mitchell*

International Photographer vol. 27, Nov. 1955
New Lightweight VistaVision Camera (p. 5) *W. R. Greene*
The Use of Filters with Kodachrome (p. 21) *R. W. Sumner*

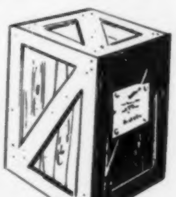
Kinematograph Weekly vol. 464, Nov. 10, 1955
Anamorphic Filming from Air in 16mm (p. 33) *W. E. Oliver*

Kino-Technik vol. 9, Oct. 1955
Neue Filmverfahren bestimmen Form und Gestaltung der Lichtspieltheater (p. 342)
Lichtspieltheater für 3D- und Breitschirmverfahren (p. 348)
Stereophonische Tonwiedergabe erfordert gute Akustik (p. 351)
Moderne Beleuchtung als Mittel der Raumgestaltung (p. 354)
Aufbau und Gestaltung moderner Tonanlagen für Filmtheater (p. 356)
Das Todd-AO-Verfahren in der praktischen Bewahrung (p. 365)

Philips Research Reports vol. 10, no. 5, Oct. 1955
Phosphors for Tricolour Television Tubes (p. 305) *A. Bril and H. A. Klasens*

PSA Journal vol. 21, Nov. 1955
CinemaScope for 16mm—The Vidoscope 16 Lens (p. 28) *B. Brooks*

Tele-Tech and Electronic Industries vol. 14, Nov. 1955
G. E. Unveils New 3-Gun Color TV Tube (p. 83)



new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Smallest dynamic microphone ever developed for radio and television broadcasting—a "thumb-size" RCA device which weighs 2.3 oz. — is now marketed by RCA's Broadcast and TV Equipment Dept. It measures only $2\frac{9}{16}$ in. in length and $\frac{15}{16}$ in. in diameter. So small that it can be carried completely concealed in the hand, it can also be worn conveniently around a performer's neck or clipped to lapel or dress. Designed for walk-around operation, the new RCA microphone (BK-6B) plugs directly into the studio console and requires no tubes or special power supply.

A pressure actuated type, the miniature "mike" is engineered for frequency response and directional scope to complement the characteristics of speech and provide the balance essential for efficient off-mike broadcasting. It has a frequency response of 80 to 12,000 cycles. It is equipped with lanyard and a 30-ft flexible cable.

The Model 105 Farnsworth Infrared Viewer is a product of Farnsworth Electronics Co., Fort Wayne, Ind. It is for use in photographic work, medical and biological research and hot body observation (above 250 C). The viewer specifications are a 1C16-3 Farnsworth tube, wavelength response of 0.4 to 1.2 microns, with resolution of 400 lines/in. The lens is a 4-in. $f/2.0$ Raptar. There is a special eyepiece and $\frac{1}{4}$-20 screw tripod mount. Power supplies for specified a-c or d-c voltages can be supplied. The standard supply is 115-v, 60 cycles, 15-w, with an output voltage of 16 kv. There are accessories of infrared sources and lens adapter.

An English edition of ***Grossbild Technik,*** a German quarterly dealing with large-negative photography, has been announced. *Grossbild Technik* deals particularly with the technical and aesthetic aspects of advanced photography and with the use generally of the camera in science, industry, criminology, advertising, fashion and other specialized fields of advanced work.

Published in cooperation with the Linhof Camera Co. of Munich, the English edition will be distributed in this country by Kling Photo Corp., 235 Fourth Ave., New York, sole agents for Linhof cameras. Issued quarterly, single copies will sell for 75 cents through photo dealers and bookstores. Annual subscriptions will be $3.00.

Size of the publication is $9 \times 11\frac{1}{4}$ in. The illustrations, both black-and-white and color—many full page—are representative of the finest work in the graphic arts. It is expected that *Grossbild Technik* will also draw considerable readership from this field, and from artists, designers and art directors. The first issue apperaed in December.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Animator leaving military service desires position with industrial or TV film producer. College degree in motion-picture production. Experience includes animated TV commercials and 2 years with U.S. Air Force in graphic animation. Thorough knowledge of field including layout design, key drawings and in-betweens, and photography on Acme stand. Letters and films on request. Lt. Louis O. Hertz, P.O. Box 462, Valparaiso, Fla.

One-Man Productions. M.A. Communications. Five years experience in every aspect of 16mm productions, color, sound and newsreel. Seeks interesting and challenging assignment here or abroad. Elliott H. Butler, 110 East Grand St., Mount Vernon, N.Y.

16mm Cameraman. All phases of 16mm and 35mm motion picture photography. Also film strip production and industrial still photography. Have own equipment for both motion picture and still. Would like position with studio or industrial concern in New York or New Jersey. Leslie Crocker, 24 Brookwood Dr., Maplewood, N.J.

Writing-Production Team. Completely and well equipped for 16mm color and sound. Operating own script to answer print studio since 1952. Seeks incorporation into organization or company as production department. Also interested in working exclusively for organization or person requiring extensive location and production work in or out of U.S.A. Complete references, background resumes and production sample on request. Write: Clark and Conkling, Box 1161, Reading, Pa.

Positions Available

16mm Processing Technician. Excellent opportunity for top-notch man; must be neat, orderly, accurate and possess knowledge of photographic chemistry. Send resume of background and experience to Eugene F. Fischer, Fischer Photographic Laboratory, Inc., 1731 N. Mobile Ave., Chicago 39, Ill.

Electronic Specialists for basic and applied research on new devices for military use. End items in this field are mine detectors and related equipment resulting from basic and applied research in electronics, electromagnetic field and radiation theory, information theory, statistics and geophysics. Applicants must hold a degree in electrical engineering, physics or mathematics, or have considerable practical research experience in their fields. Salaries range from $4345 to $8940 per year, commensurate with education and experience. Write to: Walter H. Spinks, Acting Executive Officer, Engineer Research and Development Laboratories, Fort Belvoir, Va.

General Engineer, GS-11, salary $6300 per annum. Requirements: A degree in engineering plus two and one-half years of progressive professional experience in electronic and mechanical engineering; *or* six and one-half years successful and progressive experience in technical engineering. Specialized experience in recording processes and recording equipment is desired. Send resume, complete information, to Industrial Relations Dept., Office of Naval Research, Special Devices Center, Port Washington, L.I., N.Y.

Mechanical Design Engineers—Senior Grade. Openings immediately available. Basic knowledge of the professional motion-picture production cycle necessary, with specific emphasis on laboratory functions. A knowledge of 16mm and 35mm printers would be helpful, but is not required. For interview telephone AM 2-1600 or wire to George L. Oakley, c/o Bell & Howell Co., 7100 McCormick Rd., Chicago 45.

Motion Picture and Still Photography. Growing producer in South has excellent opportunity for experienced man. Must also have editing experience. Give resume and references in first letter. Continental Productions Corp., 539 Vine St., Chattanooga, Tenn.

Professional Services

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News Columns

Advertisers

Meeting Calendar

American Institute of Physics, 25th Anniversary Celebration, Jan. 30–Feb. 4, 1956. *Includes meetings of:*
- American Assoc. of Physics Teachers, Jan. 30
- American Physical Society, Jan. 30–Feb. 4
- Optical Society of America, Feb. 1
- Acoustical Society of America, Feb. 1
- Society of Rheology, Feb. 1

All the above meetings at Hotel New Yorker, New York.

American Physical Society, Jan. 30–Feb. 4 (see above); Feb. 24–25, Rice Institute, Houston, Tex.

Optical Society of America, Feb. 1 (see above); April 5–7, Bellevue-Stratford, Philadelphia; Oct. 18–20, Lake Placid Club, Essex County, N. Y.; Mar. 7–9, 1957, Hotel Statler, New York.

Microwave Techniques, National Symposium, sponsored by IRE, Feb. 2–3, 1956, Univ. of Pennsylvania, Philadelphia.

High-Speed Photography, Third International Congress, including exhibit of high-speed photographic and cinematographic equipment and instrument aids; sponsored by Britain's Dept. of Scientific and Industrial Research, Sept. 10–15, 1956, London.

National Audio-Visual Convention, July 20–25, 1956, Hotel Sherman, Chicago.

National Electronics Conference, Inc., 12th Annual Conference, Oct. 1–3, 1956, Hotel Sherman, Chicago.

SMPTE Central Section, Feb. 20, Mar. 19, Apr. 16, May 21, June 18

American Society for Engineering Education, Jan. 26, 1956, Marquette University, Milwaukee.

Association of Cinema Laboratories, Jan. 26, 1956, New York.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 30–Feb. 3, 1956, Hotel Statler, New York.

Royal Photographic Society of Great Britain, Scientific and Technical Group, Annual Meeting, Mar. 15, 1956, London.

Inter-Society Color Council, Annual Meeting, April 5–6, 1956, Hotel Statler, New York.

International Symposium on Nonlinear Circuit Analyses, II; sixth of a series sponsored by the Polytechnic Institute of Brooklyn, Apr. 25–27, 1956, Engineering Societies Building, New York.

ASME-Engineering Institute of Canada Joint Meeting, May 23–25, 1956, Mount Royal Hotel, Montreal.

American Society of Mechanical Engineers, Sept. 10–12, 1956, Denver.

Theatre Owners of America, Inc., Annual Convention, Sept. 19–25, 1956, Coliseum, New York.

National Association of Educational Broadcasters, Oct. 1956, Atlanta.

79th Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29–May 4, 1956, Hotel Statler, New York.

80th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles.

81st Semiannual Convention of the SMPTE, Apr. 28–May 3, 1957, Shoreham Hotel, Washington, D.C.

82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6–11, 1957, Hotel Statler, New York.

83rd Semiannual Convention of the SMPTE, April 20–26, 1958, Ambassador Hotel, Los Angeles.

84th Semiannual Convention of the SMPTE, Oct. 19–24, 1958, Sheraton-Cadillac, Detroit.

85th Semiannual Convention of the SMPTE, May 3–8, 1959, Fontainebleu, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–10, 1959, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1955 Journal.

sustaining members

of the Society of Motion Picture and Television Engineers

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- Universal Pictures Company, Inc.
- Warner Bros. Pictures, Inc.

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- A Division of Union Carbide and Carbon Corporation

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Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Polaroid Corporation
Producers Service Co.
Projection Optics Co., Inc.
Radiant Manufacturing Corporation
Radio Corporation of America, Engineering Products Division
Reid H. Ray Film Industries, Inc.
Raytone Screen Corp.
Reeves Sound Studios, Inc.
S.O.S. Cinema Supply Corp.
SRT Television Studios
Shelly Films Limited (Canada)
The Stancil-Hoffman Corporation
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United Amusement Corporation, Limited
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Alexander F. Victor Enterprises, Inc.
Wenzel Projector Company
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company